TOYOTA
ERVICE TRAINING

Training Manual

Vol. 16

Charging System

Step 2

EAM

Pub.No. TTM216EN

FOREWORD

This Training Manual has been prepared for the use of technicians employed by Toyota's overseas distributors and dealers. This manual, "Charging System", is Volume 16 of the eighteen Training Manuals which constitute Step 2 of the program of skills which all Toyota New TEAM* technicians should master. It should also be used by the instructor in conjunction with the accompanying Instruction Guide.

The titles of the New TEAM Step 2 Training Manuals are as follows:

VOL.	TRAINING MANUALS	VOL.	TRAINING MANUALS
1	Gasoline Engine	10	Suspension System
2	Fuel System	11	Steering System
3	Ignition System	12	Wheel Alignment & Tires
4	Emission Control System	13	Brake System
5	EFI (Electronic Fuel Injection)	14	Fundamentals of Electricity
6	Diesel Engine	15	Starting System
7	Clutch & Manual Transaxle/Transmission	16	Charging System
8	Propeller Shaft, Differential, Drive Shaft & Axle	17	Body Electrical
9	Automatic Transaxle/Transmission	18	Heater & Air Conditioning System

It is not enough just to "know" or "understand"– you need to master each task so that you can *do* it. For this reason, theory and practice have been combined in this Training Manual. The top of each page is marked either with a  symbol to indicate that it is a Theory page or a  symbol to indicate that it is a Practice page.

Note that in regards to overhaul procedures, this Training Manual contains only the main points to be learned; please refer to the relevant Repair Manual(s) for details.

The following notations often occur in this manual, with the meanings as explained:

CAUTION	A potentially hazardous situation which could result in injury to people may occur if instructions are not followed.
NOTICE	Damaged to the vehicle or components may occur if instructions are not followed.
NOTE	Notes or comments not included under the above two headings.
REFERENCE	Information not required to pass the TEAM certification, but which may be useful to instructors and to trainees who wish to gain a deeper knowledge of the subject.

*TEAM: TEAM stands for "Technical Education for Automotive Mastery", which is a training program divided into three steps according to the technician's technical level. This program makes it possible for technicians to receive the appropriate training for their level in a systematic manner so as to help them achieve the skills and efficiency of skilled technicians in the shortest possible time.

This Training Manual explains various automotive mechanisms based on the Toyota Corolla (AE Series). However, representative models other than the Corolla have sometimes been selected to explain mechanisms not found on the Corolla. In this way, explanations of as many mechanisms as possible have been included.

For those mechanisms which have not been included in this manual, please refer to the Repair Manual for the relevant model and apply the knowledge acquired through studying the Training Manual to carry out the necessary work.

All information contained in this manual is the most up-to-date at the time of publication. However, we reserve the right to make changes without prior notice.

TOYOTA MOTOR CORPORATION

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CHARGING SYSTEM

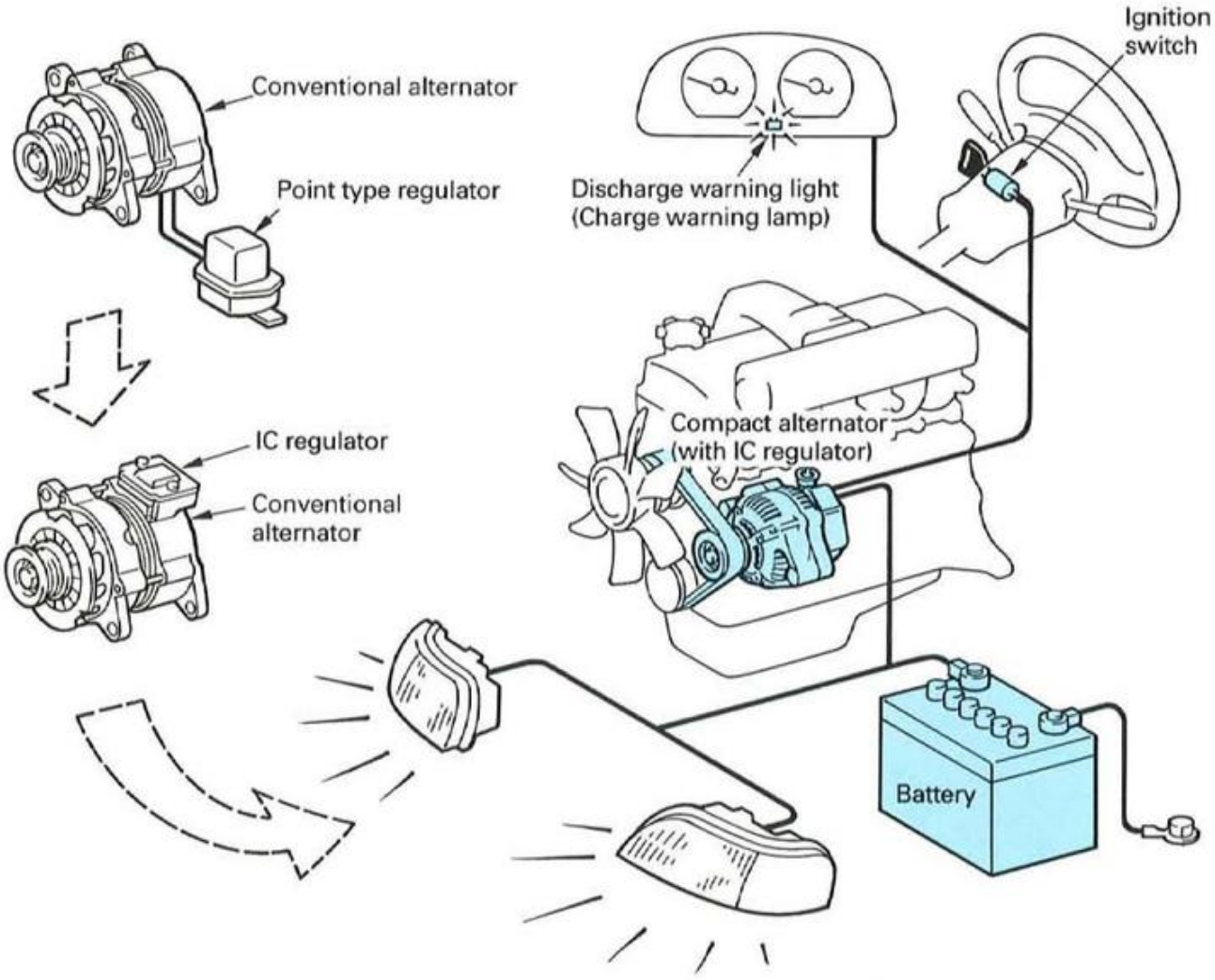
DESCRIPTION

The function of the automobile battery is to supply a sufficient amount of electricity to the automobile's electrical components such as the starter motor, headlights and wipers. However, the battery is limited in its capacity and is not capable of providing, on a continuing basis, all the power required by the automobile.

It is necessary, therefore, for the battery to always be fully charged in order for it to supply the necessary amount of electricity at the required time to each of the electrical components. Consequently, the automobile requires a charging system to produce electricity and keep the battery charged.

The charging system produces electricity to both re-charge the battery and to supply the electrical components with the amount of electricity required while the automobile's engine is in operation.

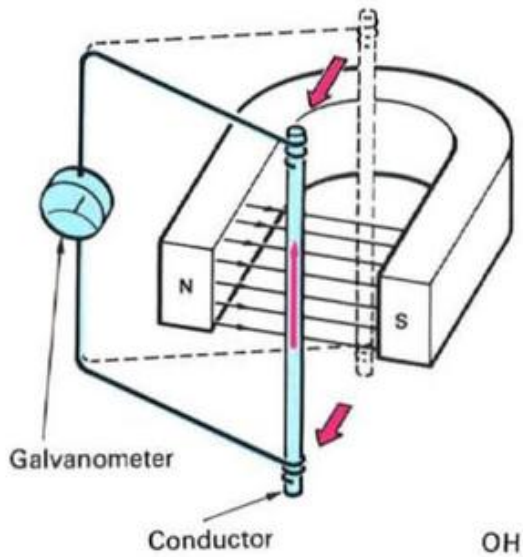
While the conventional alternator and the point-type voltage regulator were used in the past, recent vehicles mainly use a more compact alternator with a built-in IC regulator.



PRINCIPLE OF GENERATION OF ELECTRICITY

ELECTROMAGNETIC INDUCTION

When magnetic flux is cut by an electrical conductor moving within a magnetic field, electromotive force (induction voltage) will be created in the conductor, and a current will flow if the conductor is part of a complete circuit.



OHP 2

As shown in the illustration, the needle of a galvanometer (an ammeter which is activated by even the slightest amount of current) will move due to the electromotive force created when a conductor is moved back and forth between magnetic north and south poles. From this action we can observe that:

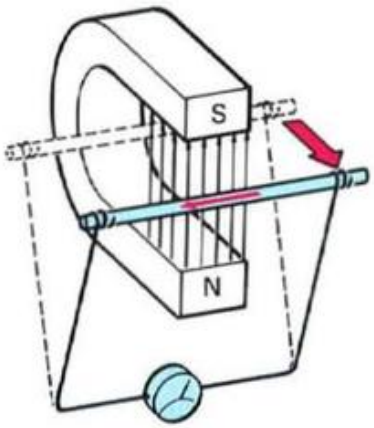
- The needle of the galvanometer will move when either the conductor or a magnet is moved.
- The direction in which the needle deflects will vary with the direction the conductor or magnet is moved.
- The extent of needle deflection will be greater in proportion to the speed of movement.
- The needle will not move when movement is stopped.

If, by some means, the conductor is caused to pass through the magnetic flux, electromagnetic force will be created in the conductor. This phenomenon is referred to as "electromagnetic induction". The generator produces electromotive force by means of electromagnetic induction, and turns this into electrical power (voltage and current).

DIRECTION OF ELECTROMOTIVE FORCE

The direction of the electromotive force generated in a conductor within a magnetic field will vary with changes in the direction of the magnetic flux and the direction in which the conductor moves. If a conductor is moved (in the direction indicated by the large arrow in the illustration below) between the magnetic north and south poles, the electromotive force will flow from right to left (the direction of the magnetic flux is from the north to the south pole).

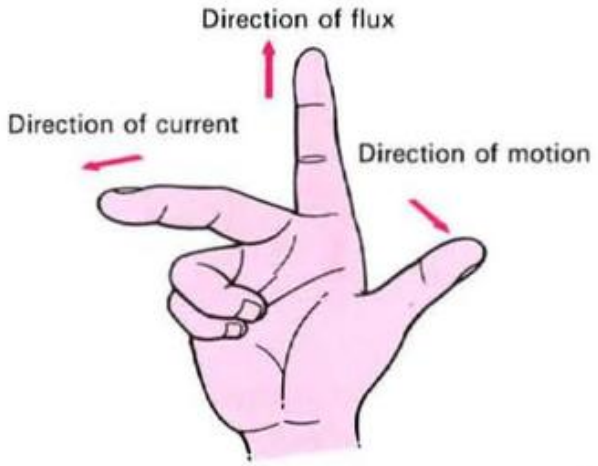
The direction of the electromotive force can be understood by use of Fleming's Right-hand Rule.



OHP 2

FLEMING'S RIGHT-HAND RULE

With the thumb, forefinger and middle finger of one's right hand are outstretched at right angles to each other, the forefinger will indicate the direction of the magnetic flux (magnetic lines of force), the thumb the direction of conductor movement, and the middle finger the direction of the electromotive force.

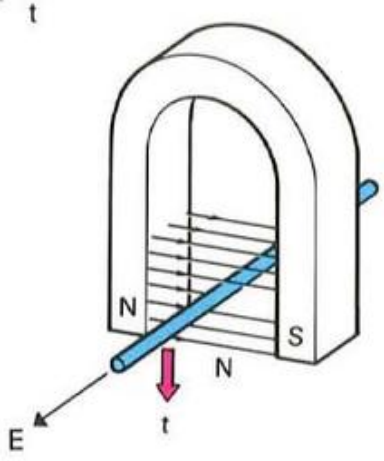


OHP 2

AMOUNT OF ELECTROMOTIVE FORCE

The amount of the electromotive force generated when a conductor cuts (passes through) the magnetic flux within a magnetic field is proportional to the number of magnetic lines of force which are cut within a given unit of time. For example, if N number of lines are cut within t seconds and the electromotive force is E volts, this can be expressed in the following formula (the symbol $\propto$ means "is proportional to"):

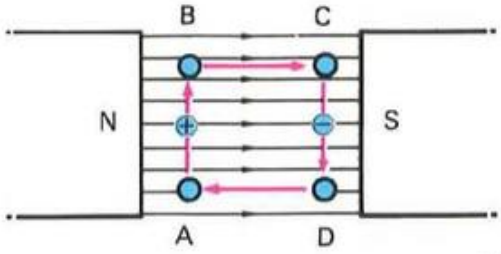
$$E \propto \frac{N}{t}$$



OHP 3

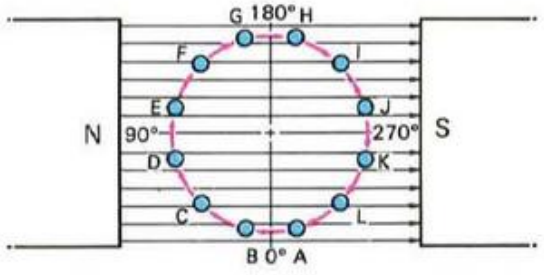
In a magnetic field of uniform density, the amount of the generated electromotive force will vary with the direction of the movement of the conductor even if the speed of the conductor remains constant. As shown in the illustration, a conductor is moved from points A to B to C to D and back to A.

However, it cuts the flux only when moving from points A to B and from C to D. In other words, although the conductor is moving at the same speed between each point, electromotive force is being generated only while it moves between A and B and between C and D.



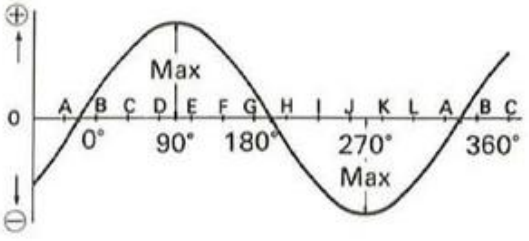
OHP 3

If the conductor is moved along a circular path within the magnetic field, the amount of the electromotive force will change constantly. In this illustration, the conductor is moved in a circle at a constant speed from point A to point L between the magnetic north and south poles. In this case, the largest number of magnetic lines of force are cut between points D and E and between points J and K, but no lines are cut between points A and B or points G and H.



OHP 3

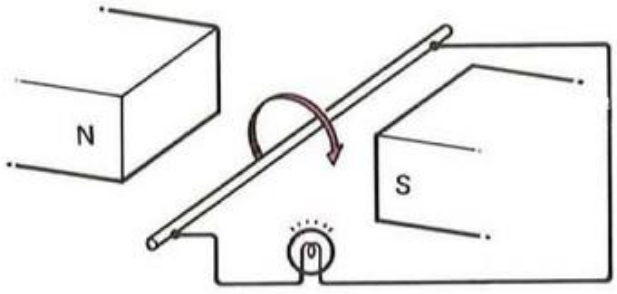
Thus, if the electromotive force generated when the conductor is moving in a circle is expressed in a graph, it can be seen that the extent of this force is constantly undergoing a change (increasing and decreasing). Further, the direction of the current generated by this electromotive force will change with each half turn of the conductor.



OHP 3

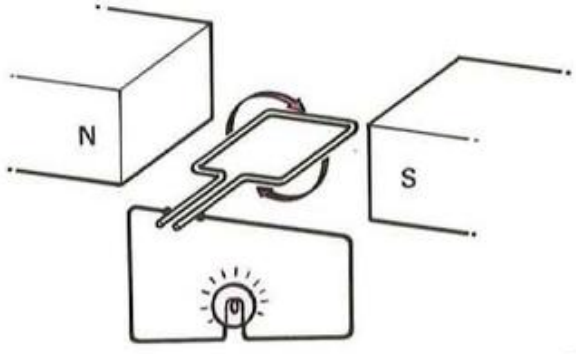
PRINCIPLE OF THE GENERATOR

Although electromotive force is produced when a single conductor is revolved in a magnetic field, the amount of force produced is actually very small.



OHP 4

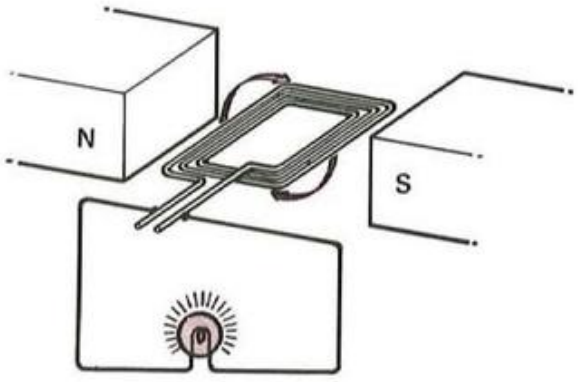
However, if two conductors are joined end-to-end, electromotive force will be created in both and, consequently, be doubled. Thus, the more conductors revolving within a magnetic field, the more electromotive force will be generated.



OHP 4

If the conductor is in the form of a coil, the total amount of generated electromotive force will be greater as will the amount of the electricity (voltage and current) produced. The generator produces electricity by revolving a coil within a magnetic field.

There are two types of electricity, direct current and alternating current and, depending on the method of producing electricity, generators are either direct-current or alternating-current types.



OHP 4

NOTE

Generation of electromotive force:

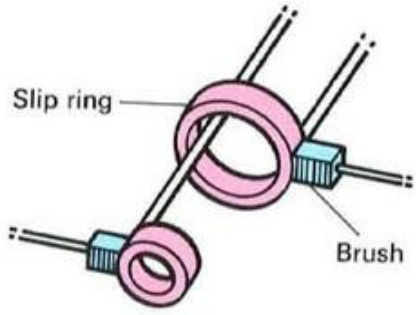
- When a conductor moves in the magnetic field, electromotive force is created in the conductor.
- When the direction of the conductor movement changes, the direction of the current that is generated by the electoromotive force also changes.

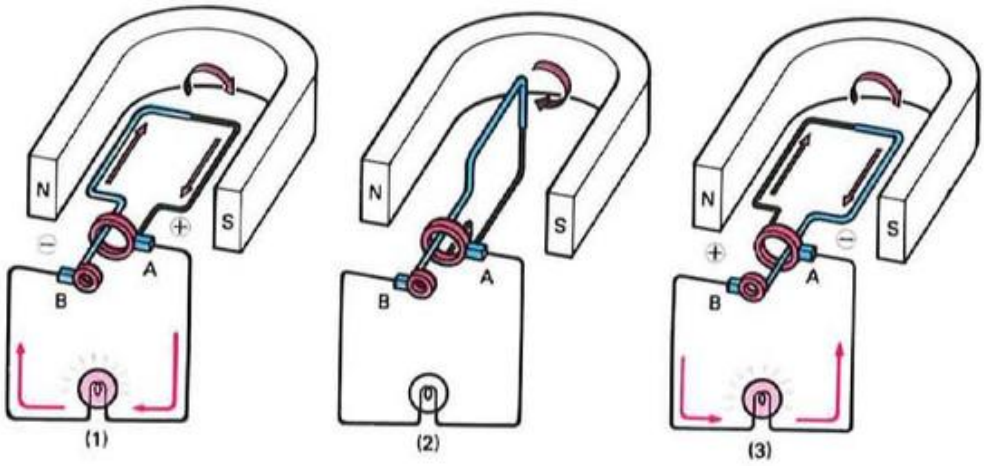
Size of electromotive force:

- The larger the magnetic field, the larger the electromotive force.
- The faster the conductor movement, the larger the electromotive force.
- The higher the number of conductors (coil windings), the larger the electromotive force.

ALTERNATING-CURRENT GENERATOR

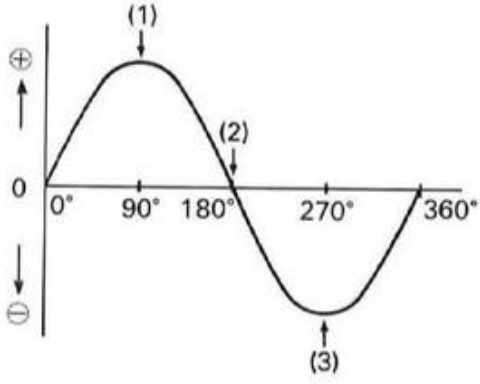
When electricity generated by a coil is supplied through slip rings and brushes (so the coil can rotate), the amount of current flowing to the lamp will change and, at the same time, so will the flow direction.



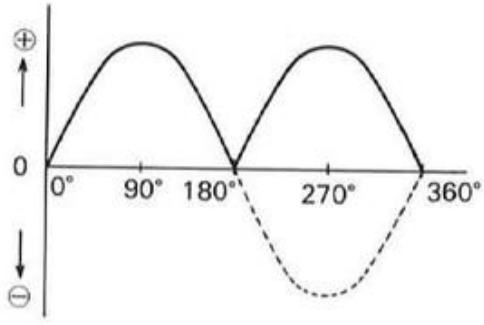


OHP 5

As the coil rotates, the current generated on the first half of the turn will be supplied from the brush on side A, pass through the lamp and then return to the brush on side B.
On the latter half of the turn, the current will be supplied from side B and return to side A.



In this fashion, the alternating-current generator supplies the current generated by the coil in a magnetic field. The alternator used in the charging system of an automobile utilizes diodes to rectify the current (i.e., change it to direct current) immediately before it is supplied to the charging system.



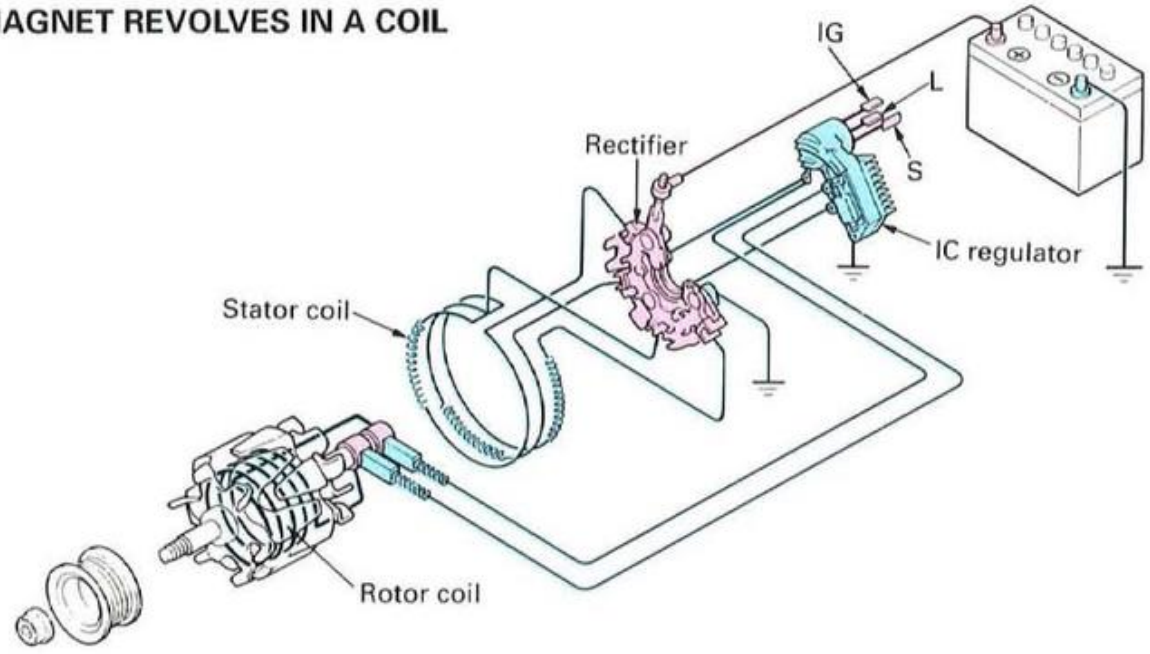
REFERENCE

In an actual generator, several magnets and coils are used to prevent the amount of the current from changing.

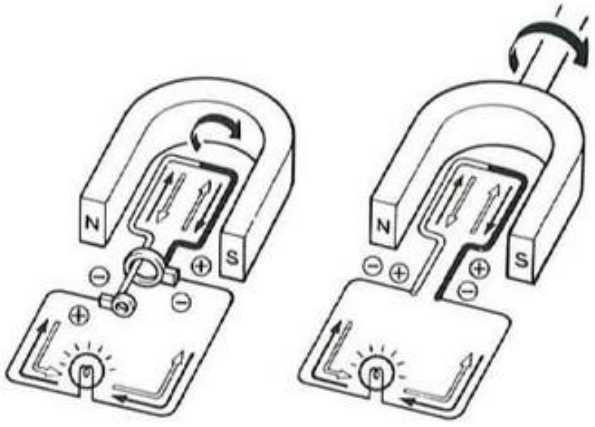
ALTERNATOR

PRINCIPLE OF THE ALTERNATOR

1. MAGNET REVOLVES IN A COIL

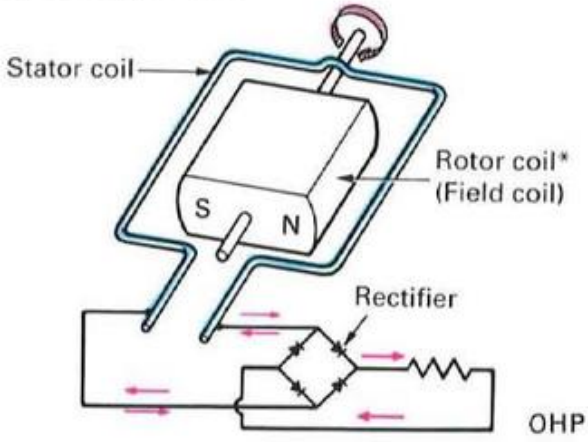


The previous section described how rotating the coil in a magnetic field generates electricity in the coil. Note however, that electricity can also be generated in the coil if the coil merely interrupts the lines of magnetic force. To do so, with the coil remaining stationary, the magnet can be rotated to generate electricity in the coil. Also, by doing so, the construction of the generating device can be made more simple.



Therefore, all alternators used on automobiles today utilize a generating coil (stator coil) with an internally rotating magnet (rotor coil*). Thus, the alternating current generated in the stator coil is changed into direct current by the rectifier.

* The rotor coil may also be called a "field coil", indicating the type of coil that is used for creating magnetic poles in an electrical motor or generator.



OHP 7

2. COIL PRODUCES ELECTROMAGNET

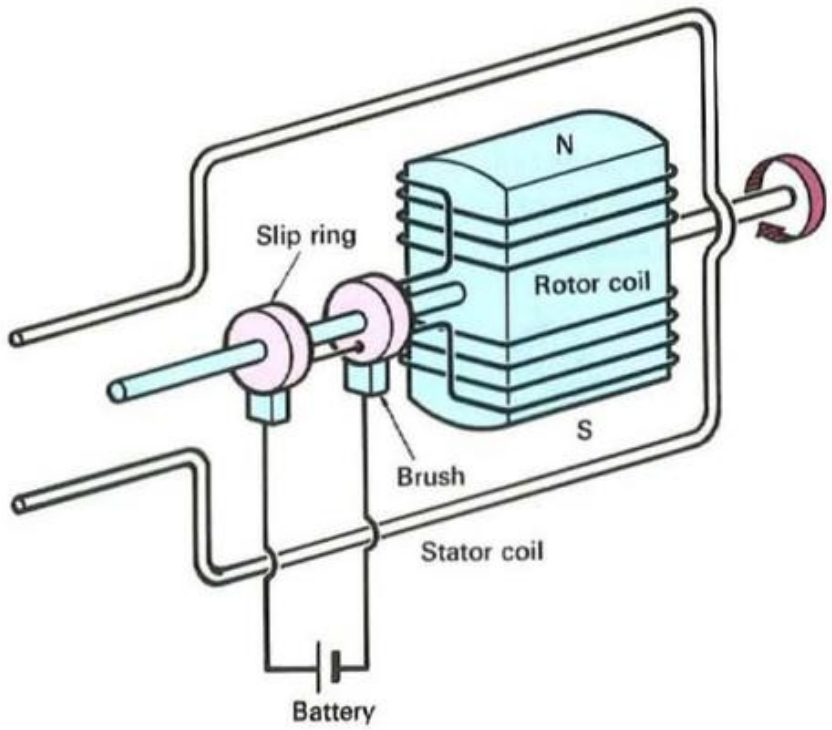
Normally, the electrical components of an automobile utilize either 12 or 24 volts of electricity, and the alternator for the charging system must supply this voltage.

Electricity is generated when a magnet is rotated within a coil and the amount of this electricity varies with the speed of magnet rotation. Thus, through the process of electromagnetic induction, the faster the coil cuts the magnetic lines of force from the magnet, the more electromotive force the coil will generate. We can see, then, that voltage changes depending on the speed with which the magnet rotates.

Accordingly, to obtain a constant voltage, it is necessary to rotate the magnet at a constant speed. However, because the engine operates at various speeds, depending on the driving conditions, the speed of the alternator cannot be kept constant.

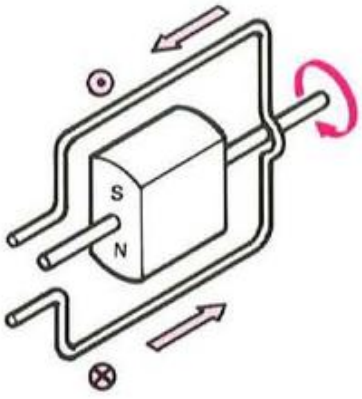
To solve this difficulty, an electromagnet can be used instead of a permanent magnet to maintain a fixed voltage. The electromagnet changes the amount of magnetic flux (number of magnetic lines of force) in accordance with the rpm of the alternator.

The electromagnet has an iron core with coils wrapped around it. When current flows through the coils, the core is magnetized. The extent of the generated magnetism varies with the amount of current flowing through the coil. Thus, when the alternator is rotating at a low speed, current is increased and, conversely, current is decreased when the alternator is turning at high rpm. The current flowing through the electromagnet is supplied by the battery and the amount is controlled by the voltage regulator. For this reason, the alternator supplies a constant voltage regardless of the engine speed.



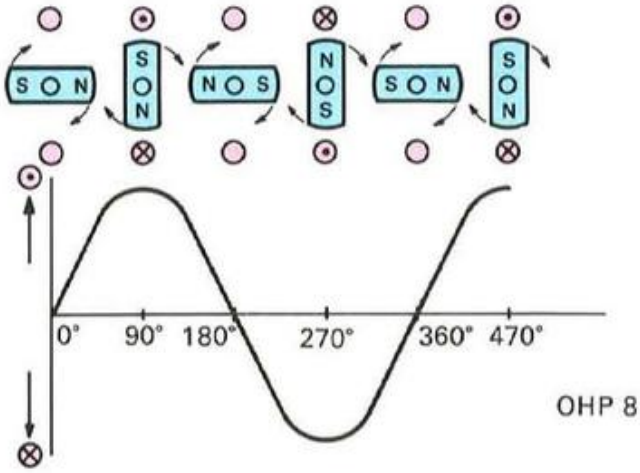
3. THREE-PHASE ALTERNATING CURRENT

When a magnet rotates within a coil, a voltage will be created between each end of the coil. This will give rise to an alternating current.



OHP 8

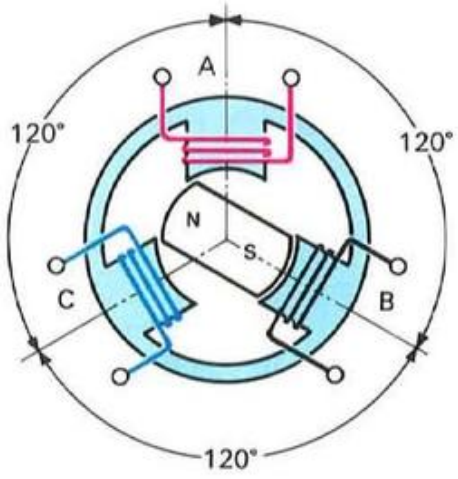
The relationship between the current generated in the coil and the position of the magnet is as shown in the illustration. The largest amount of current is generated when the N and S poles of the magnet are closest to the coil. However, the current flows in opposite direction with each half turn of the magnet. Current which forms a sine wave in this manner is called "single phase alternating current". A change of 360° in the graph is referred to as one cycle and the number of changes occuring in one second is called the "frequency".



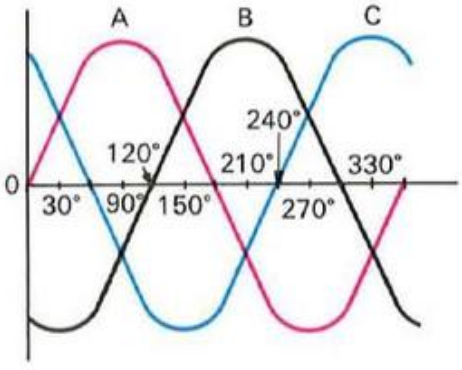
OHP 8

To generate electricity more efficiently, the automobile alternator uses three coils arranged as shown in the illustration.

Each coil, A, B, and C, is spaced 120° apart. When the magnet is rotated among them, alternating current is generated in each coil. The illustration shows the relationship between the three alternating currents and the magnet. Electricity having three alternating currents like this is referred to as "three-phase alternating current"; all modern automobile alternators generate three-phase alternating current.



OHP 8



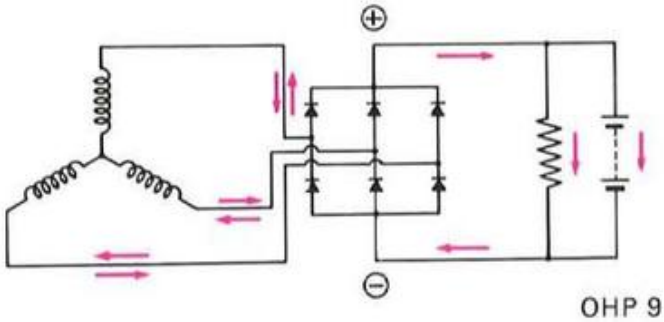
OHP 8

4. RECTIFICATION

The electrical components of an automobile require direct current for operation and the battery needs direct current for charging.
The alternator produces three-phase alternating current but the charging system of the automobile cannot use this electricity unless it is converted to direct current.

Converting alternating current to direct current is called rectification. Rectification can be accomplished in several ways but the automobile alternator uses a simple but effective diode.

A diode allows current to flow in one direction only. As shown in the illustration, when six diodes are used, the three-phase alternating current is converted to direct current by full wave rectification. As the automobile alternator has built-in diodes, the electricity output is direct current.



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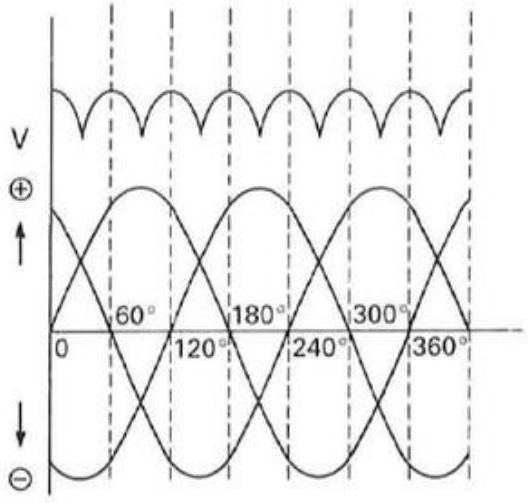
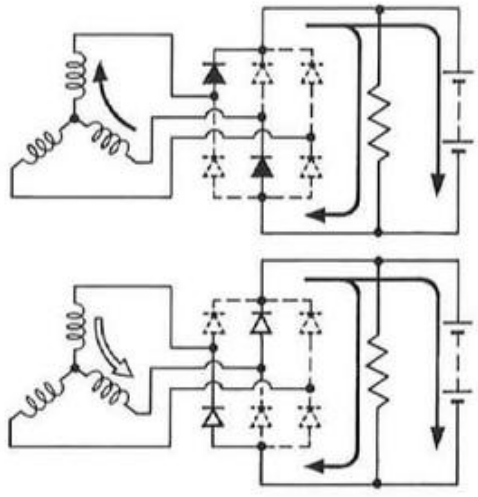
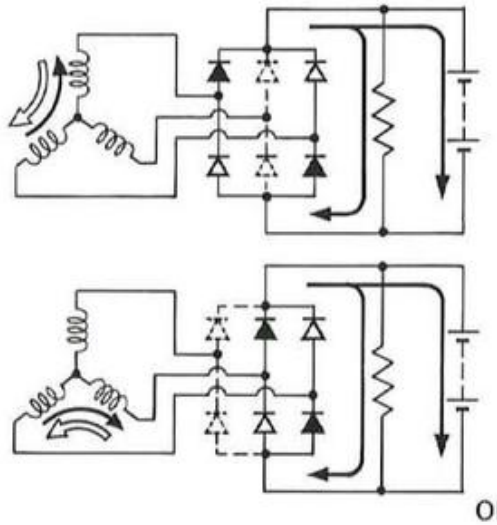


OHP 9

Thus, we can see that although the current from each coil to the diodes is constantly changing direction in the three lead wires, the direction of the current from the diodes does not change and it forms a circuit with unvarying polarity.





OHP 10

NOTICE

1. **Some high-performance alternators employ more than six diodes**
2. **If the battery connections are reversed, the diodes will be damaged due to a large current flow.**

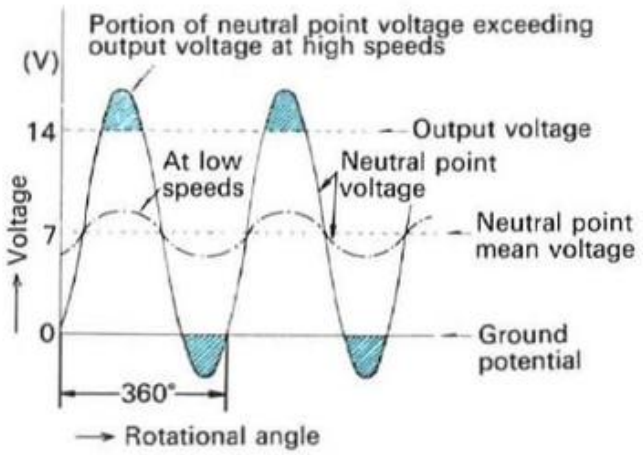
ALTERNATOR WITH NEUTRAL-POINT DIODES

1. NEUTRAL-POINT VOLTAGE

A conventional alternator uses six diodes to rectify three-phase AC into DC. The output voltage which is generated at the neutral point is utilized as an electrical source for the charge lamp relay.

It is known that the mean voltage of the neutral point is 1/2 of the output DC voltage. While the output current is flowing through the alternator, the voltage at the neutral point is mostly DC, but it also includes an AC portion.

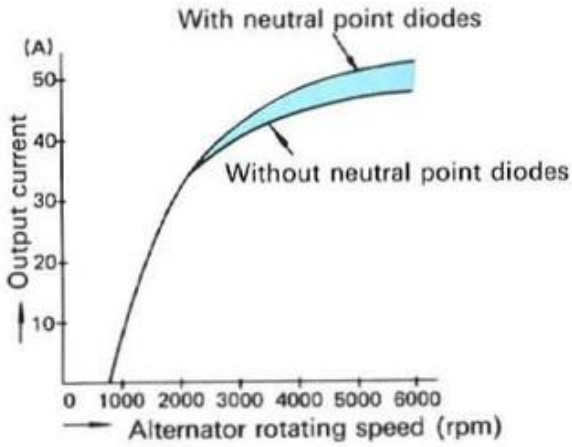
The AC portion is induced in each phase by the flow of output current. When the rotational speed of the alternator exceeds 2,000 to 3,000 rpm, the peak value of this AC portion exceeds the DC output voltage.



VOLTAGE WAVE APPEARING AT NEUTRAL POINT UNDER LOAD

OHP 11

This means that, compared with the output characteristics of the alternator without a neutral-point diode, the output gradually increases from midway by 10 to 15% at a normal rated revolution speed of about 5,000 rpm.

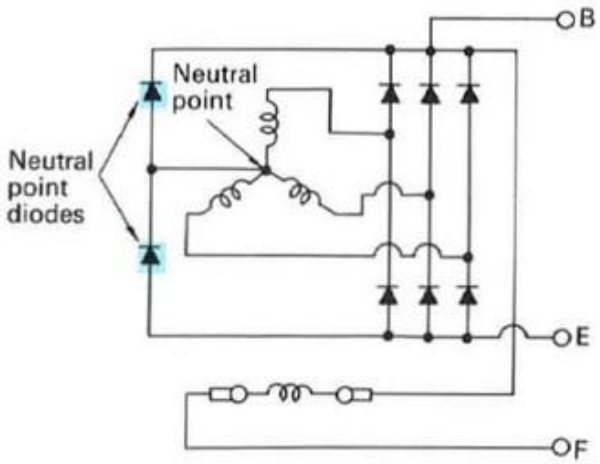


PERFORMANCE CHARACTERISTICS (EXAMPLE)

OHP 11

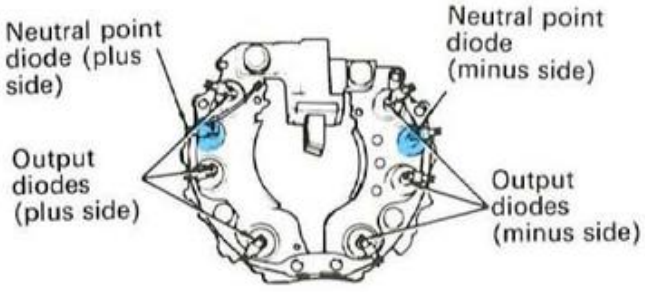
2. CIRCUITRY AND CONSTRUCTION

In order to add the potential variation at this neutral point to the DC voltage output by the alternator with neutral-point diodes, two rectification diodes are provided between output terminal (B) and earth (E) and connected to the neutral point. These diodes are installed on the rectifier holder.



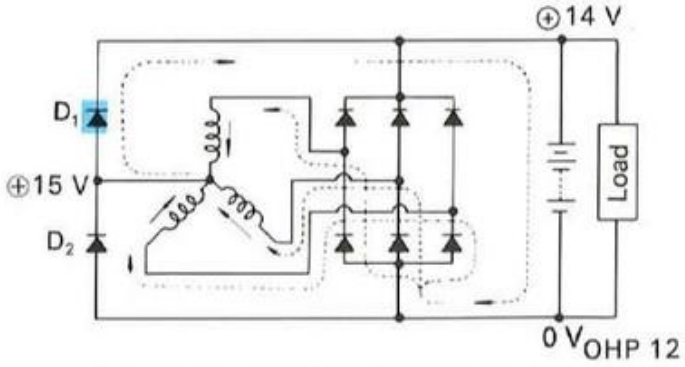
CIRCUITRY OF ALTERNATOR WITH NEUTRAL POINT DIODES (EXAMPLE)

OHP 11

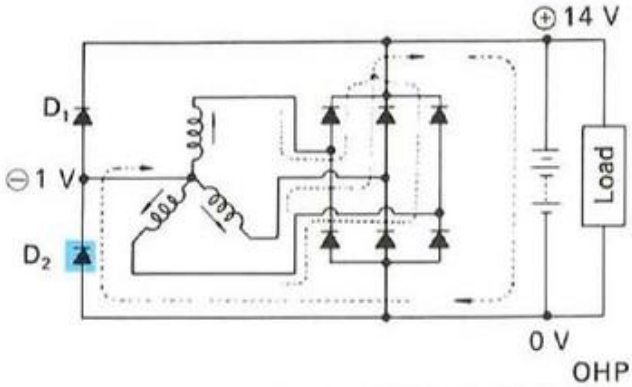


3. OPERATION

When the voltage at the neutral point becomes higher than the output DC voltage or lower than zero volts, a current flows through the neutral point diode, and this is added to the output current. (This corresponds to the shaded portion in "VOLTAGE WAVE APPEARING AT NEUTRAL POINT UNDER LOAD" graph on the previous page).



NEUTRAL POINT VOLTAGE ABOVE 14 V



OHP 12

NEUTRAL POINT VOLTAGE BELOW 0 V

3-DIODE EXCITING ALTERNATOR

This alternator is provided with three field diodes in order to excite the field coil, in addition to the usual six output diodes for rectification.

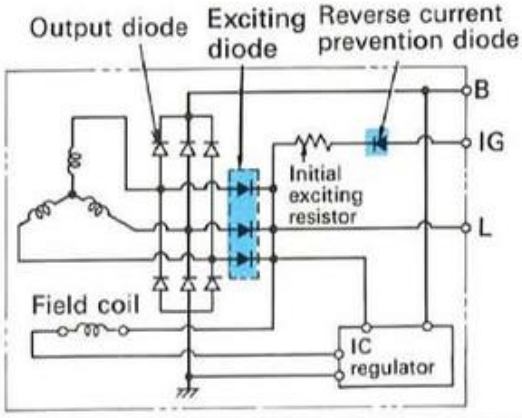
In this alternator, turning the ignition switch ON supplies field current through the reverse current prevention diode and initial exciting resistor, from the IG terminal.

Since the initial exciting resistor is contained in the circuit, the field current is as small as 0.5 A when the alternator stops with the ignition switch ON.

Therefore, the discharge from the battery is small.

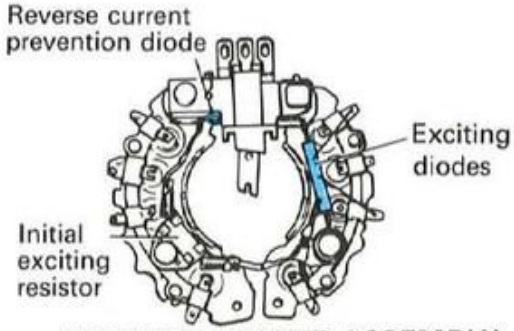
When the alternator starts to generate, a portion of the generated current is supplied directly from the three field diodes during power generation. The reduction in the field current becomes less due to the resistance of external wiring and the like and, therefore, it is possible to improve the output.

The three field diodes, the initial exciting resistor and the diode for preventing reverse current flow are all installed on the rectifier holder.



CIRCUIT DIAGRAM OF 3-DIODE EXCITING ALTERNATOR

OHP 13



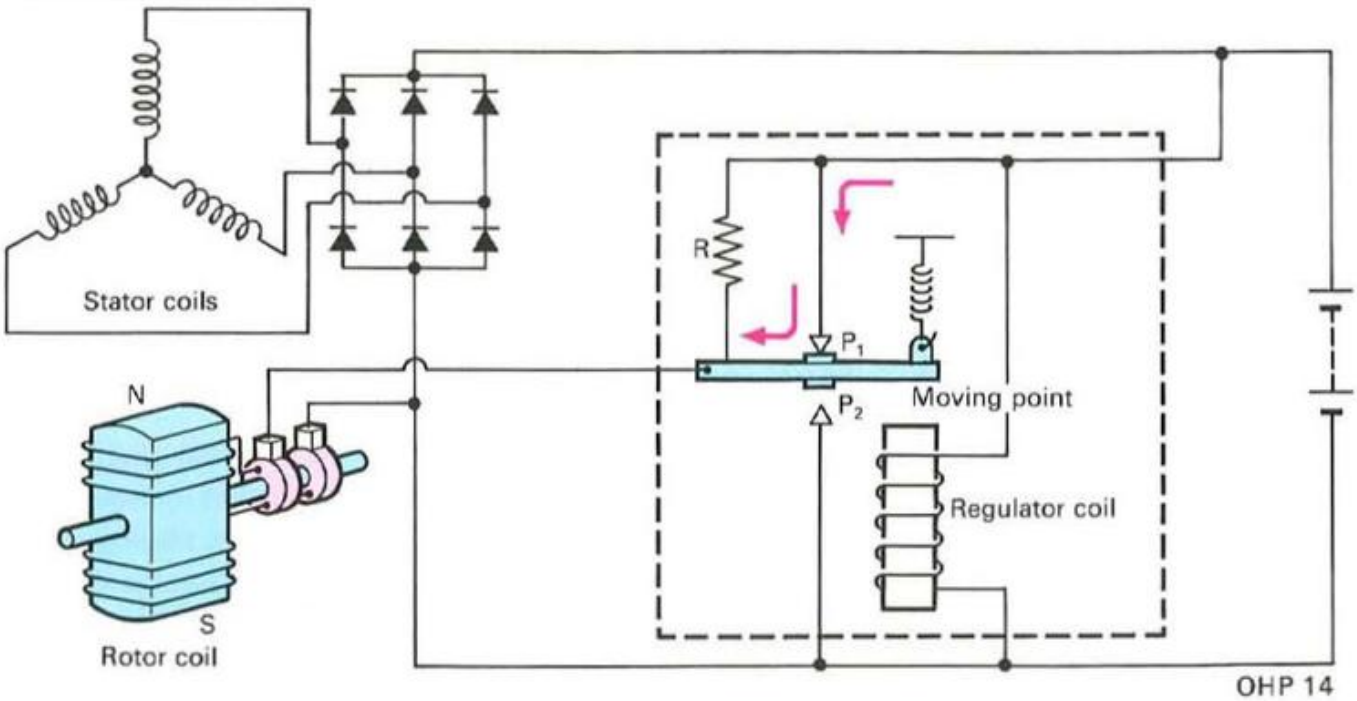
RECTIFIER HOLDER ASSEMBLY

VOLTAGE REGULATION

The voltage of the current produced by the alternator varies with the speed which the alternator is turning and the extent of the load (output current) on the alternator.

However, because the engine rpm is continuously changing, the rpm of the alternator does not remain constant. Further, the loads (lamps, wipers, heater, etc.) on the alternator are always changing along with the charging condition of the battery. Therefore, in order for the alternator to supply electricity at a constant "standard" voltage, is it necessary to control the amount of voltage with a regulator and, consequently, the charging system of the automobile uses a voltage regulator (generator regulator) along with the alternator.

As the electromagnet consists of an iron core with coils wrapped around it, the iron core is magnetized and generates magnetic lines of force (magnetic flux) when it is supplied with current.
The amount of the magnetic lines of force is in proportion to the amount of current supplied to the coil around the iron core. In other words, the generator ensures that the alternator (stator coil) is producing a constant voltage by supplying a larger amount of current to the rotor coil (field coil) when the alternator is turning at a low rpm or when it is under a heavy load, and by reducing the amount of current when the alternator is turning faster or when it is under a light load.



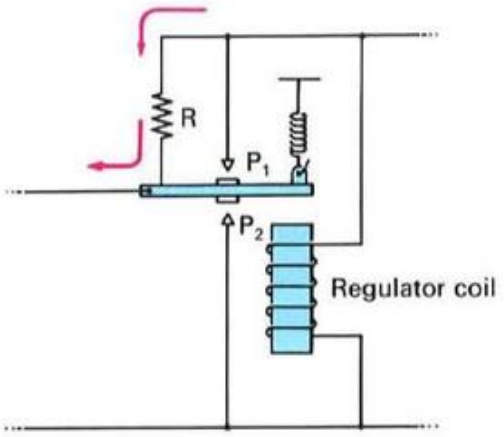
OHP 14

NOTE: Some alternators have built in regulators, such as the IC semiconductor type.

The regulator supplies current to the electromagnet (rotor coil) which produces the necessary magnetic flux for the three coils (stator coil) of the alternator to generate three-phase alternating current.

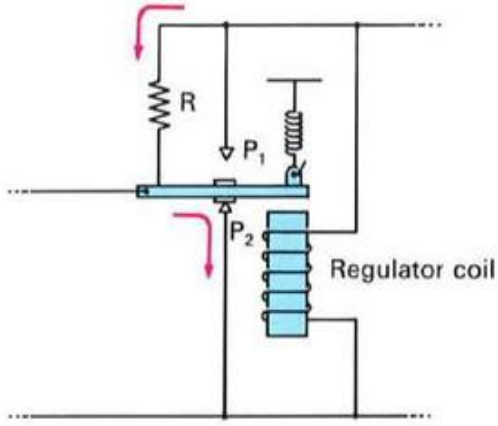
The regulator controls the supply of current to the rotor coil by pulling and releasing the moving point in accordance with the voltage applied to the regulator coil.
When the alternator is turning at a low rpm and a heavy load is applied, the voltage at the stator coil will become lower than the regulating voltage (approximately 14 V) at the regulator. Accordingly, the moving point will make contact with P_1, thus allowing the battery current to flow to the rotor coil through P_1.

On the other hand, when the alternator is turning at a high rpm and the voltage of the stator coil rises above that of the regulating voltage (approximately 14 V) at the regulator, this voltage is applied to the regulator coil so it is affected by a greater pulling force which separates it from P_1.



When the moving point moves away from P_1, the current flowing to the rotor coil passes through resistor R and therefore is reduced in intensity. Less current to the rotor coil will cause the stator coil to generate less voltage and, consequently, there will be reduced pulling force on the coil, so the moving point will return and make contact with P_1. This, in turn, causes a rise in the current to the rotor coil and the moving point again moves away from P_1.

When the alternator turns at an even faster speed, the voltage generated by the stator coil will rise, applying more pulling force to the regulator coil so that it makes contact with P_2. Therefore, the current through resistor R will then flow to P_2 and not to the rotor coil.

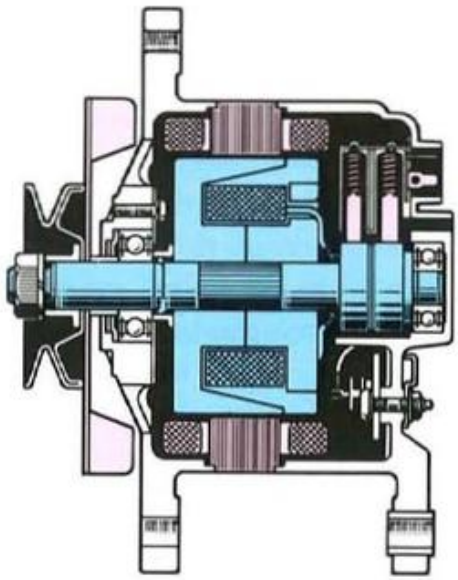


When there is no longer any current to the rotor coil, the stator cannot generate electromotive force, so the voltage of the alternator drops and the moving point moves away from P_2. Thus, once again the alternator voltage will rise and the moving point will be pulled.

In other words, when the alternator is turning at a low speed, the moving point will increase or decrease current to the rotor coil by making contact with or moving away from P_1. When the alternator is turning at a high rpm, current will be supplied intermittently to the rotor coil depending on whether the moving point is making contact with or has moved away from P_2.

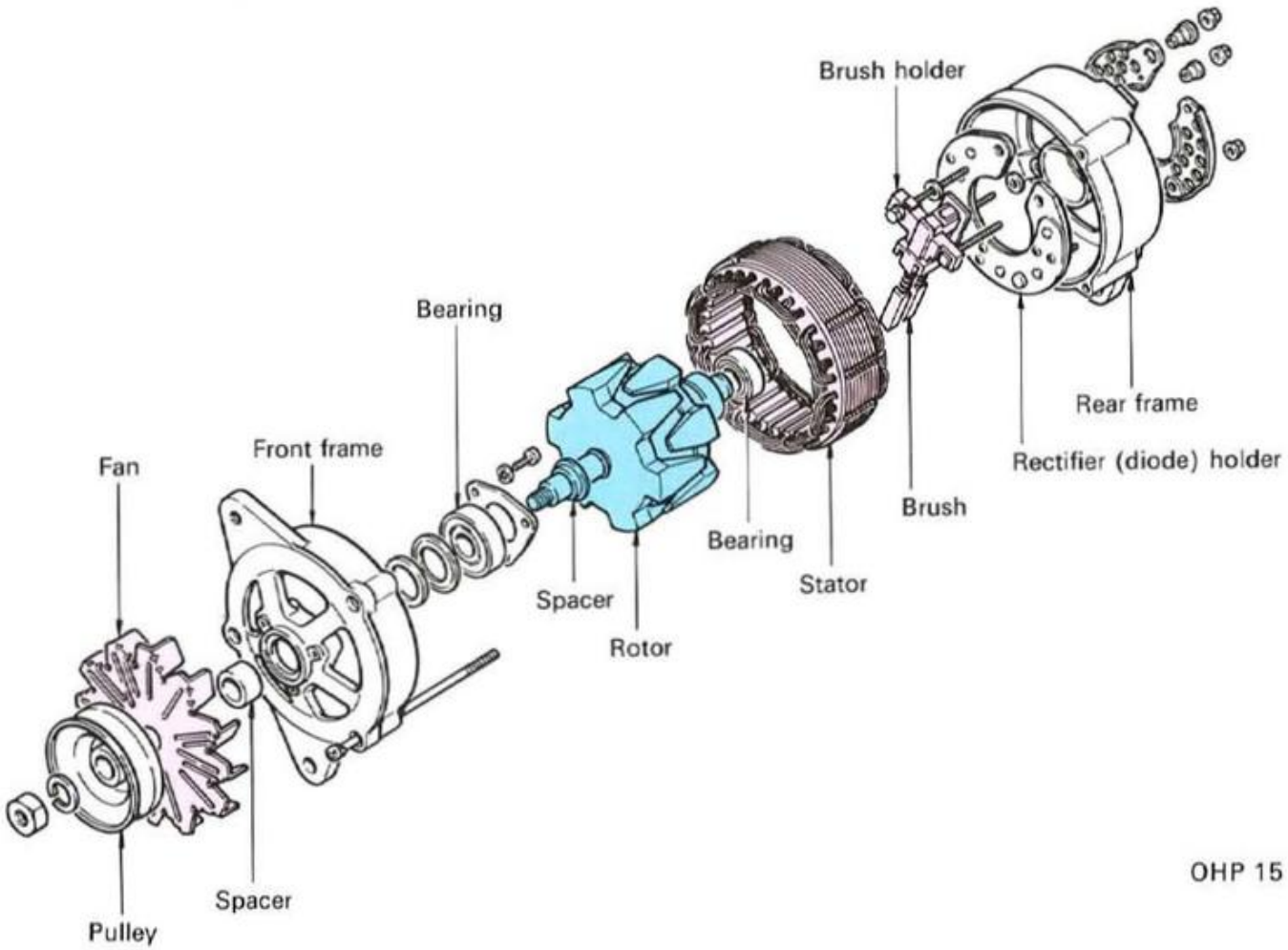
CONSTRUCTION OF THE ALTERNATOR

The function of the alternator is to convert mechanical energy from the engine into electricity. Mechanical energy from the engine is relayed by a pulley, which revolves a rotor and generates alternating current in the stator. This alternating current is rectified to direct current by the diodes.



The main components of the alternator are the rotor which produces electromagnetism, the stator which produces electric current, and the diodes which rectify the current.

In addition, there are also the brushes which supply current to the rotor for production of magnetic flux, the bearings which allow the rotor to rotate smoothly, and a fan to cool the rotor, stator and diodes. All of these components are held by front and rear frames.

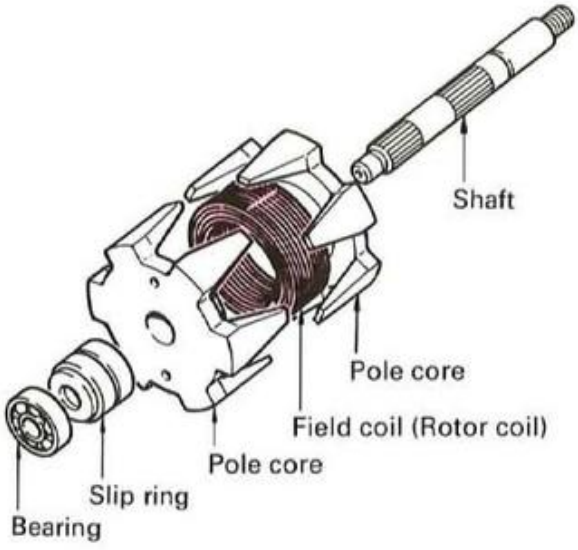


OHP 15

1. ROTOR

The rotor is composed of two cores (magnetic poles), a field coil (also called a rotor coil), slip rings, and a rotor shaft.

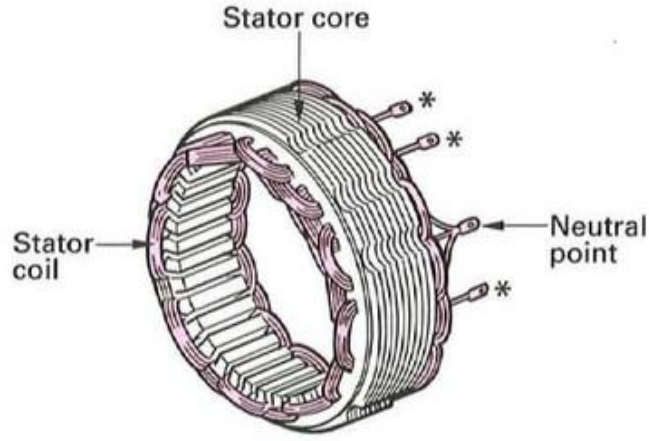
The field coil is wound in the same direction as rotation, and each end of the coil is connected to a slip ring. The two cores are installed at each end of the coil so as to enclose the field coil.
Magnetic flux is produced as current flows through the coil and one pole becomes the N pole and the other the S pole. The slip rings are made of metal such as stainless steel with a highly finished brush contacting surface. They are insulated from the rotor shaft.



2. STATOR

The stator is composed of the stator core and stator coils, and is secured to the front and rear ends of the frame. The stator core consists of thin layers of steel plating (stratified iron core). The inner side has slots in which there are three independent stator coils.

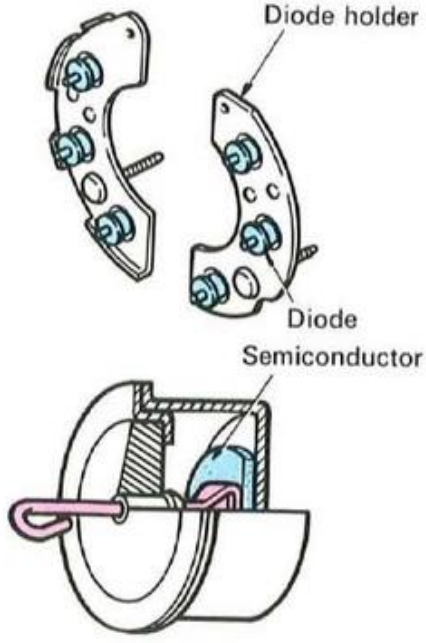
The stator core acts as a passage which allows the flux effectively cross to the stator coil from the rotor cores.



* Stator coil's output terminals (to output diode)

3. DIODES

Three positive diodes and three negative diodes are contained in their respective diode holders. The current generated by the alternator is supplied from the positive side diode holder so it is insulated from the end frames.
During rectification, the diodes become hot, so the diode holders act to radiate this heat away and prevent the diodes from overheating.



DIODE

COMPACT ALTERNATOR

A compact alternator with built-in IC regulator is 17% smaller and 26% lighter than a standard-size alternator.
The compact alternator with built-in IC regulator is constructed in the same way as a standard-size alternator (but the operation of the IC regulator is, of course, different from that of an ordinary point type regulator).
The construction and features are described here and compared with those of conventional alternators.

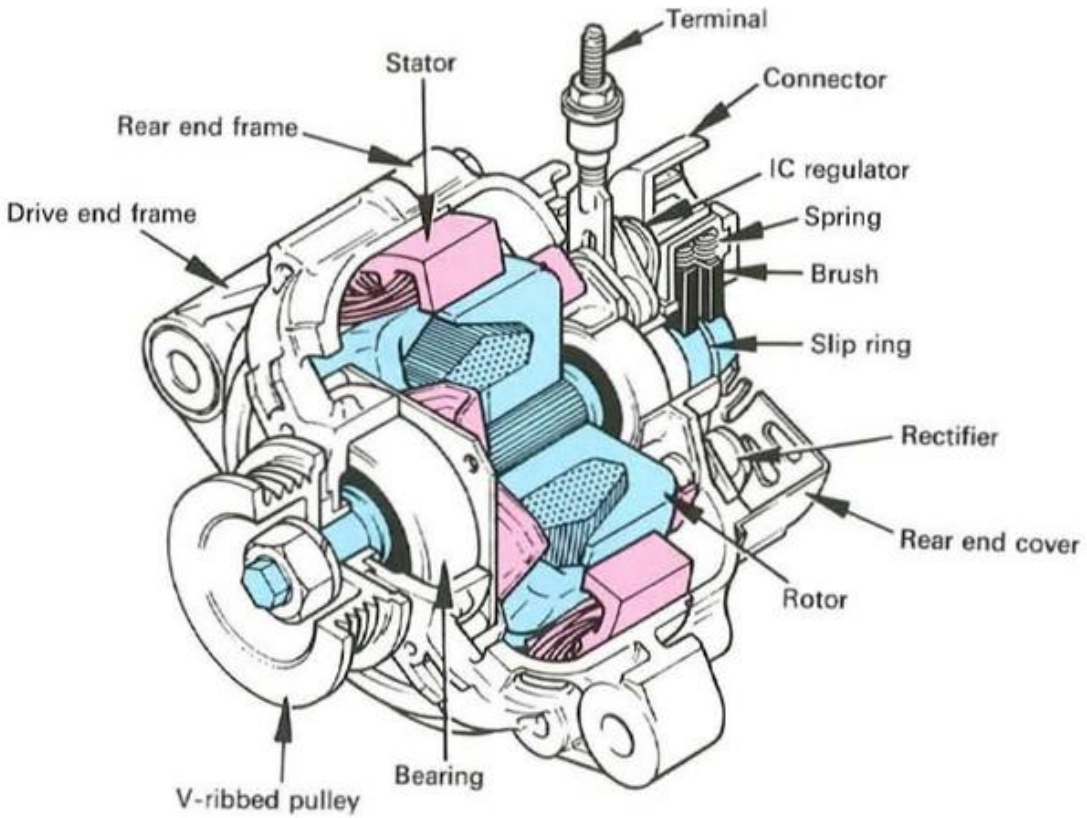
1. FEATURES

1) Smaller and Lighter
Improvements in the magnetic circuit, such as air gap reduction between rotor and stator and modification of the shape of the rotor pole cores, have been performed to achieve compactness and lightness.

2) Consolidation of Fan and Rotor
The rotational speed of the compact alternator is much faster than that of a standard-size alternator.
To cope with this change, the fan, which was conventionally placed outside, has been combined with the rotor within the alternator, resulting in improved cooling performance and safety.

3) Improved Serviceability
The rectifier, brush holders and IC regulator are secured to the end frame with bolts for easy removal and installation.

4) Simplified Charging System
The use of a multiple-function IC regulator simplifies the charging system, thus improving reliability.



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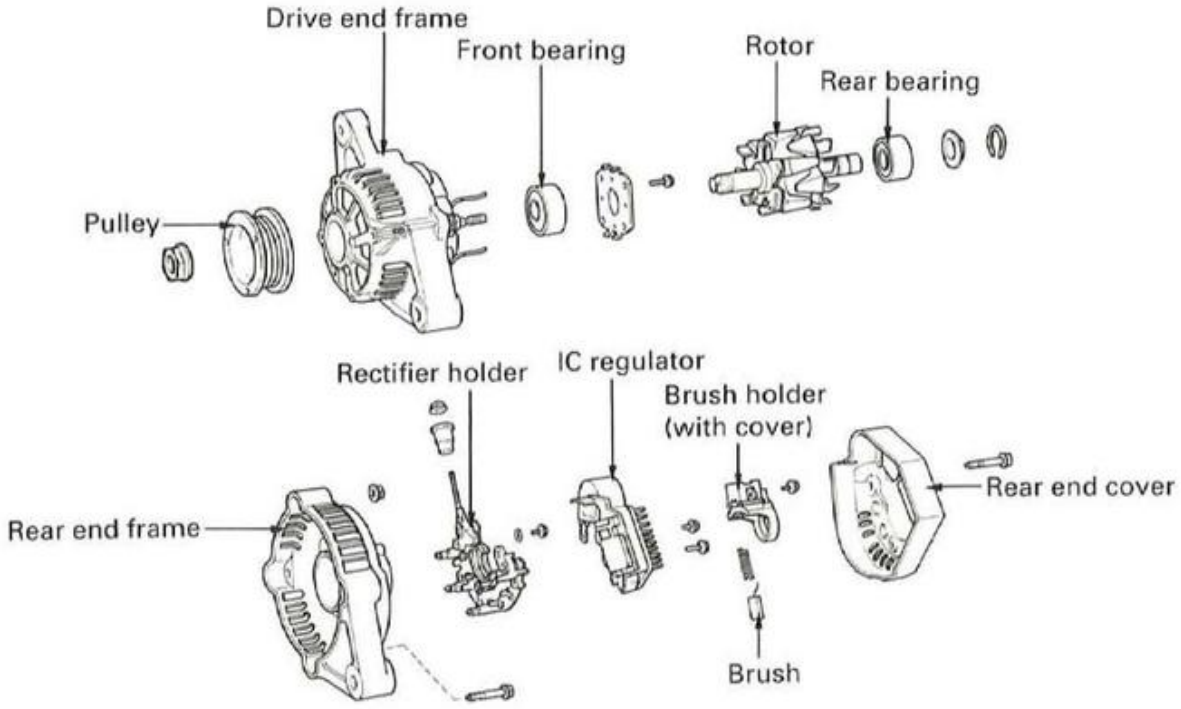
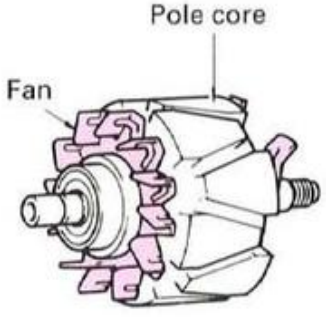
2. CONSTRUCTION



1) Rotor

The rotor functions as a field magnet and rotates integrally with the shaft. The rotor assembly is composed of a magnetic core, field coil, slip ring shaft and fan. Differing from conventional alternators, the rotor has integral fans on both sides.



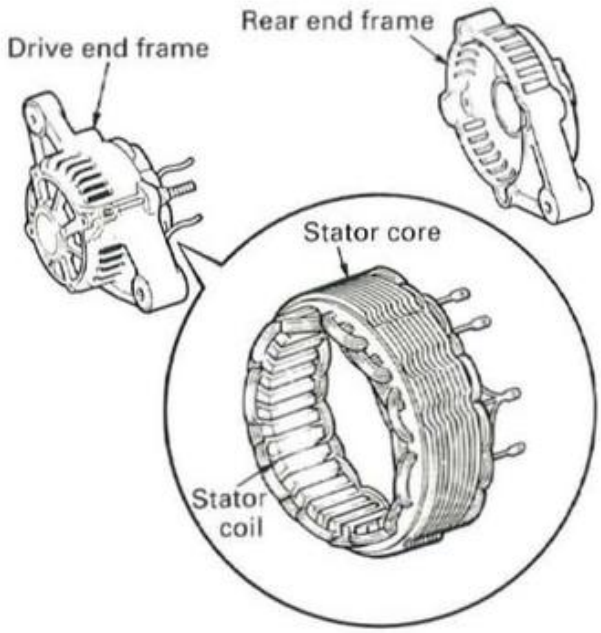
2) End Frames

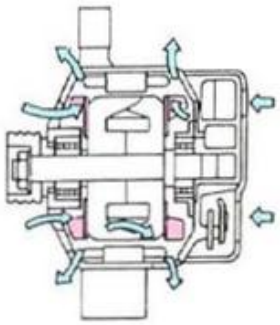
The frames have two functions: to support the rotor and to act as a mount to the engine.

Both of them have several air passages to improve cooling efficiency. The rectifier, brush holder, IC regulator, etc., are bolted to the back side of the rear end frame.

3) Stator

The stator assembly is composed of the stator core and stator coil. It is pressure-fitted to (integral with) the drive end frame. The heat generated by the stator is transmitted to the drive end frame to improve cooling efficiency.



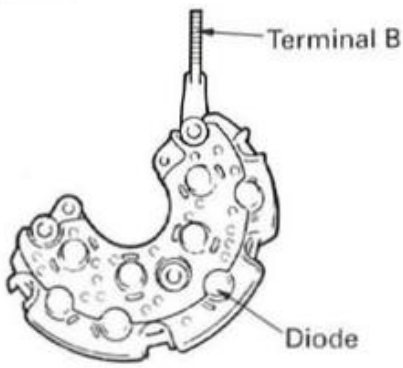


⇨ Cool air

4) Rectifier

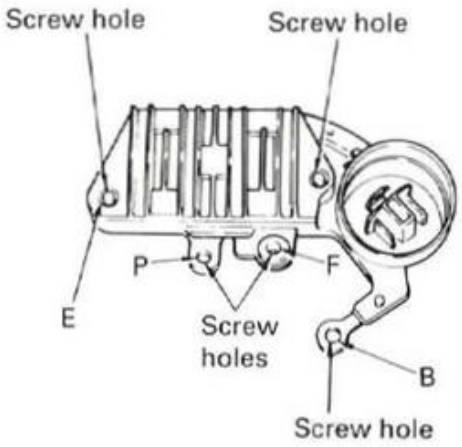
The rectifier is designed with a protrusion on its surface to help improve radiation of the heat generated due to the output current.

Also, due to its mono-body structure and the terminal-insulated connections between the diode elements, the rectifier is very compact.



5) IC regulator

The alternator has a built-in compact IC regulator. The internal circuitry of the IC regulator includes a high-quality, monolithic integrated circuit (IC) to provide improved reliability and charging.



NOTICE

The IC regulator is installed on the alternator with several screws, which are used not only to secure the IC regulator, but also to connect the alternator to the terminals E, P, F and B of the IC regulator.

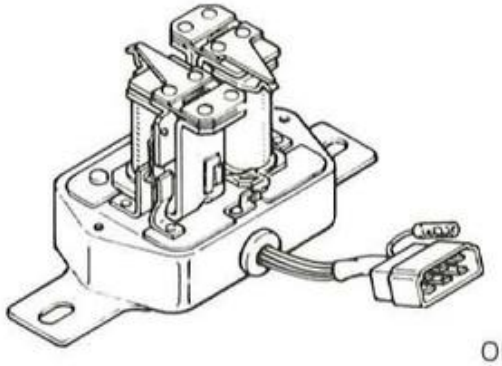
Therefore, if the screws are not securely tightened, there will be improper terminal contact, causing a drop in power generation and charging.

6) V-Ribbed Pulley

The pulley ratio has been increased about 25% by use of a V-ribbed pulley which provides better high-speed efficiency.

REGULATOR

The regulator increases and decreases the amount of field current to the rotor in order to control the amount of voltage produced by the alternator.
It is composed of points, a magnetic coil and a resistor.



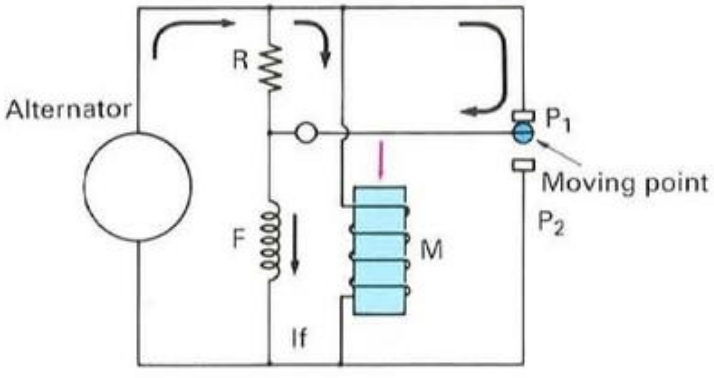
OHP 17

REFERENCE

There are also pointless type regulators. They utilize semiconductors (transistors, ICs, etc.) to control the current to the rotor.

TWO POINT TYPE REGULATOR

The two point type has a resistor (R) connected in series with the field coil (F) of the rotor.
When the voltage generated by the alternator is low, the magnetic force of the magnet coil (M) is weak, and the moving point and the low-speed point (P1) are in contact. The current from the field coil flows through these points.

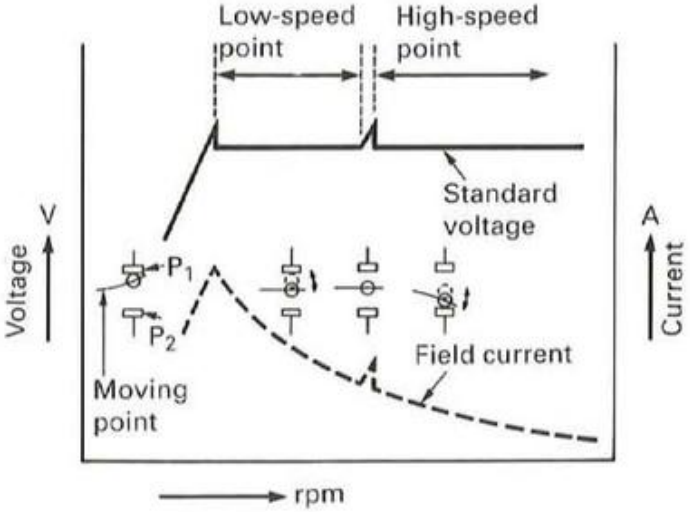


As the voltage increases, the magnetic force will become stronger, causing the moving point and the low-speed point (P_1) to open. When the points are open, current will pass through the resistor (R), and current to the field coil is thereby reduced.

As the voltage increases further, reaching the regulating voltage of the regulator, the moving point comes into contact with the high-speed point (P_2).
When the moving point is in contact with the high-speed point, field current ceases to flow.

A characteristic of the two-point type is that there is both a low-speed operating range and a high-speed operating range.

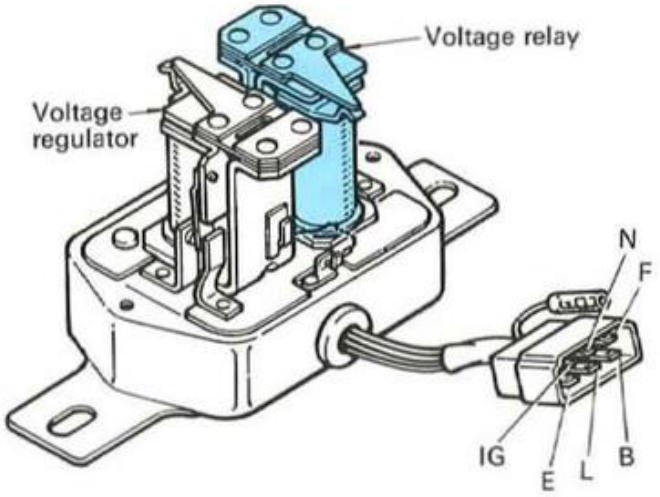
While the point-type voltage regulator was used in the past, most vehicles now use an IC regulator (see page 24).



OHP 18

VOLTAGE RELAY (CHARGE LAMP RELAY)

Instead of using only a regulator to control the voltage generated by the alternator, charging systems often employ a two-element combination of a voltage regulator and a voltage relay.



A voltage relay insures accurate voltage regulation. Because the magnetic coil of the voltage regulator operates in accordance with the voltage generated by the alternator, it is necessary to insure that there is no drop in alternator voltage.

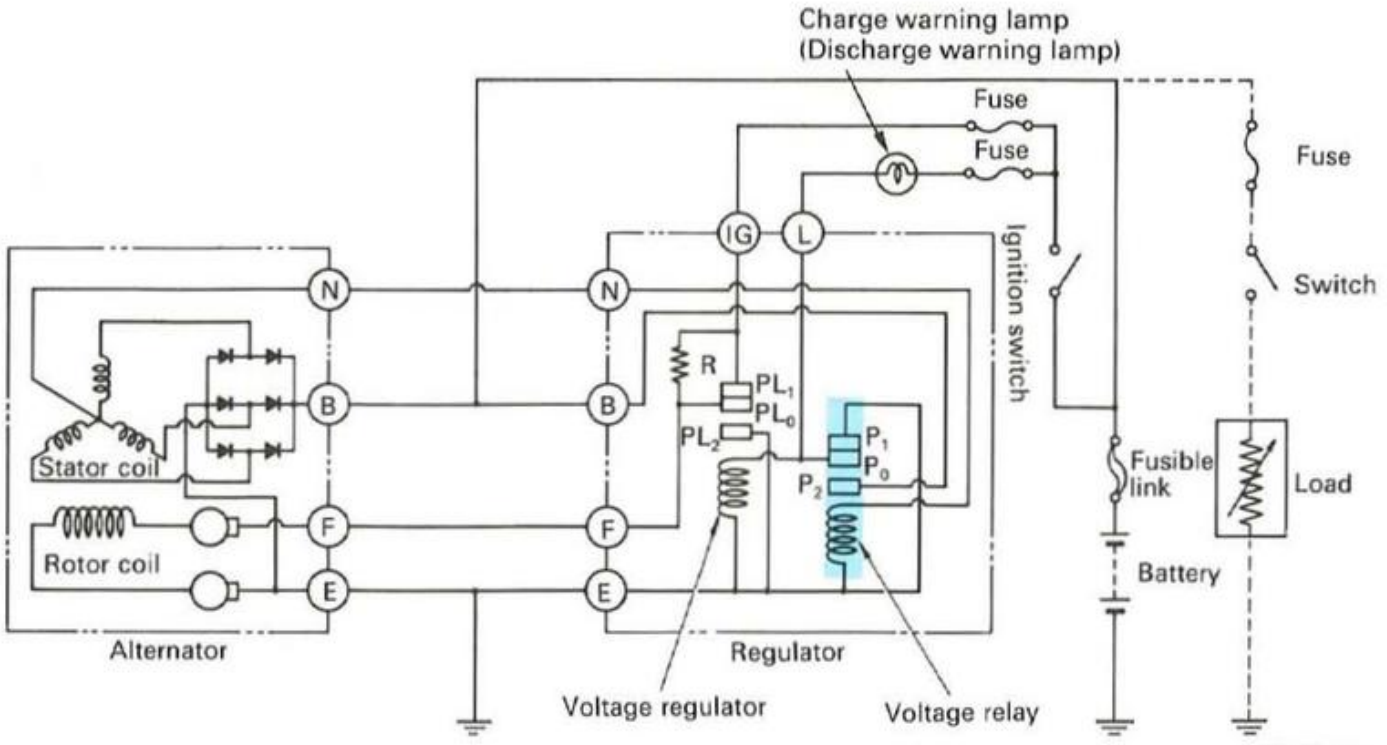
If there were no voltage relay, there would occur a drop in voltage in the magnetic coil because the voltage is applied to a long circuit via the ignition switch. A reduction in voltage would cause a proportionate decrease in magnetic force of the magnet coil so the moving points would not be pulled sufficiently. As a result, alternator voltage would raise too high.

Because the charge lamp light blinks in accordance with voltage relay operation, the voltage relay is also called the charge lamp relay.

The magnetic coil of the voltage relay is operated by the neutral voltage of the stator coil and, compared with the magnetic coil of the voltage regulator, it pulls the points with less voltage.

NOTE

Neutral voltage is half of the normal alternator output voltage.



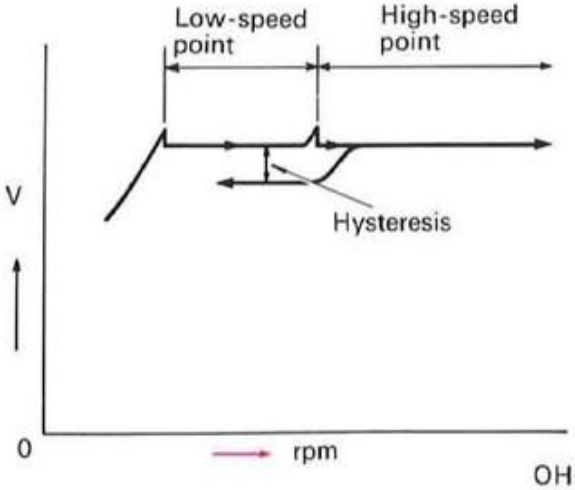
OHP 19

CHARACTERISTICS OF THE REGULATOR

The function of the regulator is to maintain the voltage generated by the alternator at a constant level. Actually, however, due to the characteristics of the generator, voltage does not remain constant but fluctuates. For the point type (Tirril) regulator, there are various reasons why voltage fluctuates but the primary causes are due to its hysteresis and temperature characteristics, and it is important to be aware of these before attempting to adjust the regulator.

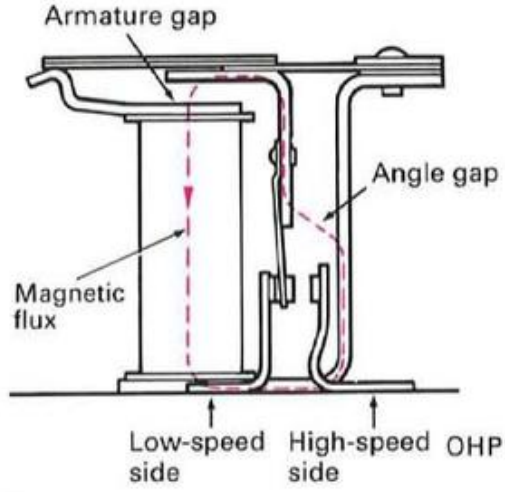
1. THE HYSTERESIS CHARACTERISTIC

When the moving points change from the high-speed point (side) to the low-speed point, a lowering of voltage occurs. This is called the hysteresis effect.



OHP 20

When the moving point is operating at either the low-speed or high-speed position, a change occurs in the armature gap and angle gap and this change results in an increase or decrease in magnetic resistance. Also, when the moving point changes from the high-speed side to the low-speed side, residual magnetism from high-speed operation remains in the coil core and continues to pull on the moving point for a short time. These two phenomena cause the alternator output voltage to decline.



OHP 20

NOTE

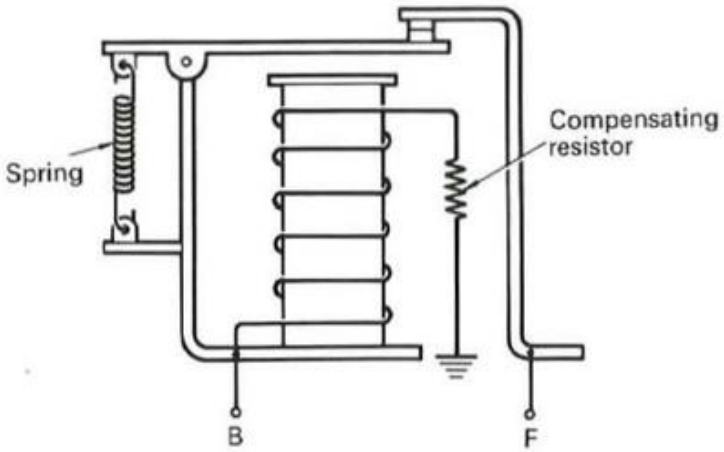
No attempt should be made to adjust the regulator when voltage is dropping due to this hysteresis effect. Generally, a 12-volt system will drop from 0.5 to 1.0 volts.

2. THE TEMPERATURE CHARACTERISTIC

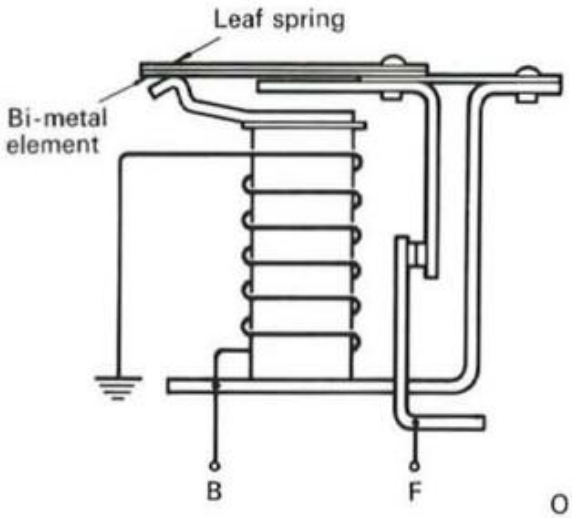
The magnetic coil of the voltage regulator employs copper wiring, and if the temperature of this wire rises, resistance will be increased and there will be a reduction in the pulling force (electromagnetic force) of the magnetic coil, resulting in a higher alternator output voltage.

To prevent such a rise in voltage, the regulator utilizes either a resistor or a bi-metal element for temperature compensation, but some regulators use both.

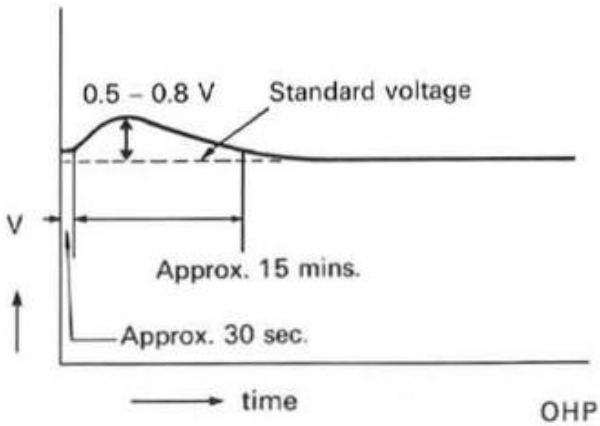
The resistor has either a Nichrome wire or a carbon element, with a low temperature resistance coefficient, and is connected in series to the coil. It reduces the ratio of the overall resistance in accordance with the temperature fluctuation.



The bi-metal element is used together with a spring which supports the moving point. The bi-metal element reduces the spring tension as the temperature rises. After the regulator begins operationing, the voltage will fluctuate until the temperature stabilizes. Once the regulator begins operating, the current causes the temperature of the magnetic coil to rise immediately. However, the rise in the temperature of the bi-metal element is slightly retarded so spring tension is strong and voltage increases.



OHP 20



OHP 20

NOTE

Normally, it takes 5 to 15 minutes for the voltage to stabilize. No attempt should be made to adjust the regulator during this time.

IC REGULATOR

DESCRIPTION

Both the point type regulator and the IC* regulator have the same basic purpose: they limit the voltage that is output by the alternator by controlling the field current which flows through the rotor coil.

The main difference is that, in the IC regulator, the field current is interrupted by an IC instead of by a relay as in the point type regulator.

REFERENCE

*IC

An IC (Integrated Circuit), is a miniturized circuit composed of many small electrical or electronic components (transistors, diodes, resistors, capacitors, etc.) mounted onto or built into a substrate (that is, a base material such as a circuit board or silicon chip).

The IC regulator is compact and light weight, and has excellent reliability due to its lack of mechanical points. Compared with the point type, it has the following features:

ADVANTAGES

- A narrower output voltage range and little variation with time in output voltage.

NOTE

Re-adjustment is not required. (In fact, no adjustment mechanism is provided.)

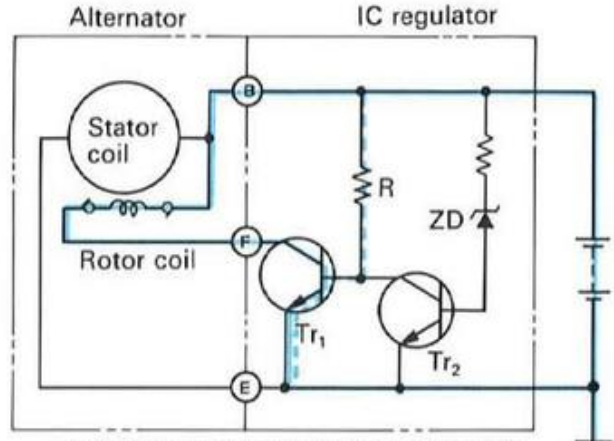
- Good resistance to vibration and high durability due to lack of moving parts.
- Since its output voltage becomes lower as its temperature rises, proper charging of the battery can be performed.

DISADVANTAGE

- Susceptible to unusually high voltages and temperatures.

OPERATING PRINCIPLE OF IC REGULATOR

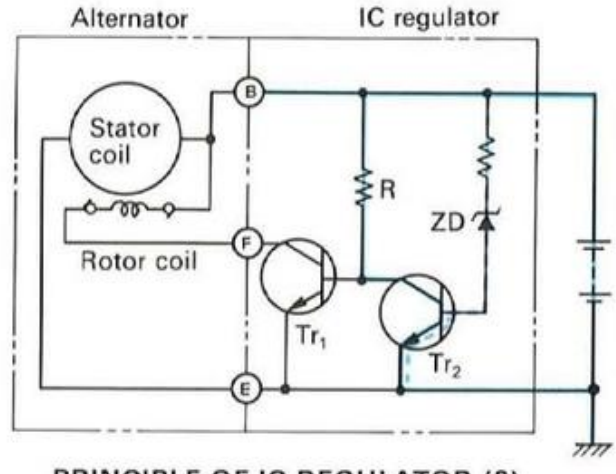
In the circuit diagram for the IC regulator in the illustration, when the output voltage at terminal B is low, the battery voltage is applied to the base of Tr_1 through resistor R, and Tr_1 turns on; at the same time, field current to the rotor coil flows from B → rotor coil → F → Tr_1 → E.



PRINCIPLE OF IC REGULATOR (1)

OHP 21

When the output voltage at terminal B is high, a higher voltage is applied to the Zener diode (ZD) and when this voltage reaches the Zener voltage*, the ZD becomes conductive. Accordingly, as Tr_2 turns on, Tr_1 turns off. This interrupts the field current, regulating the output voltage.



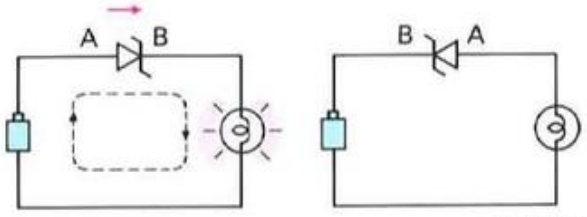
PRINCIPLE OF IC REGULATOR (2)

REFERENCE

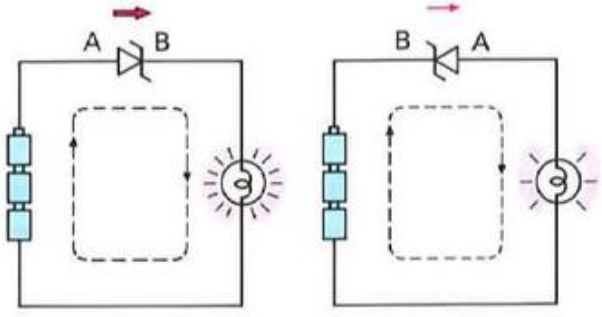
*Zener voltage

When a voltage is applied to the Zener diode in the forward direction (from A to B in the figure below), a current flows, in the same way as with normal diodes; however, when any voltage less than a certain level is applied in the reverse direction (from B to A), the Zener diode is not conductive, and a current does not flow. The difference between the Zener diode and a normal diode is that when any voltage more than a certain level is applied in the reverse direction, the Zener diode will become conductive and will allow a current to flow.

The voltage at which the Zener diode changes from non-conductive to conductive in the reverse direction is called the "Zener breakdown voltage".



OHP 22

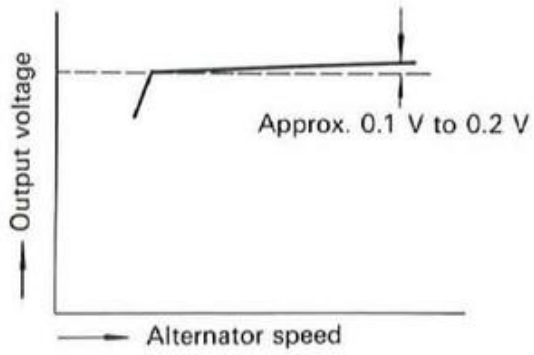


OHP 22

CHARACTERISTICS OF IC REGULATOR

1. BATTERY LOAD CHARACTERISTICS

There is little or no variation in output voltage (no more than 0.1 to 0.2 V) with changes in alternator speed, and no hysteresis characteristics as with the point type.



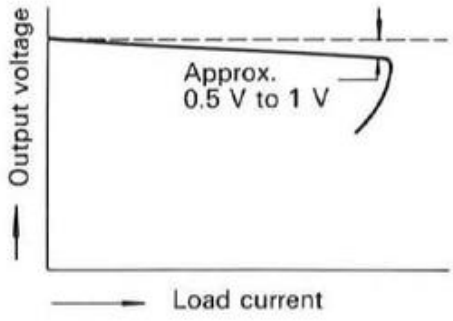
OHP 23

2. EXTERNAL LOAD CHARACTERISTICS

Output voltage becomes lower as the load current increases. There are no hysteresis characteristics as with the point type regulator: voltage variation, even at the rated load, or maximum output current of the alternator, is between 0.5 V and 1 V.

NOTICE

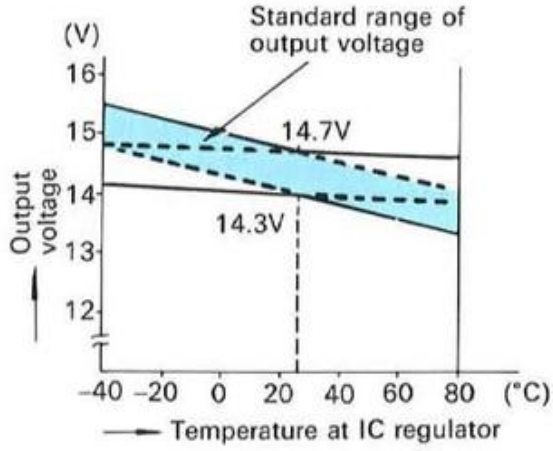
If a load exceeding the alternator's capacity is applied, the output voltage will suddenly drop, as in the case of the point type regulator. For this reason, never apply an excessive load when checking the output voltage.



OHP 23

3. TEMPERATURE CHARACTERISTICS

Since the Zener diode used for regulating the output voltage tends to become more conductive as the ambient temperature rises, the output voltage generally becomes lower as the temperature rises. Since the output voltage drops at high temperatures (e.g., during summer) and rises at low temperatures (e.g., during winter), proper charging suited to the battery's characteristics is performed at all times.



OHP 23

NOTE

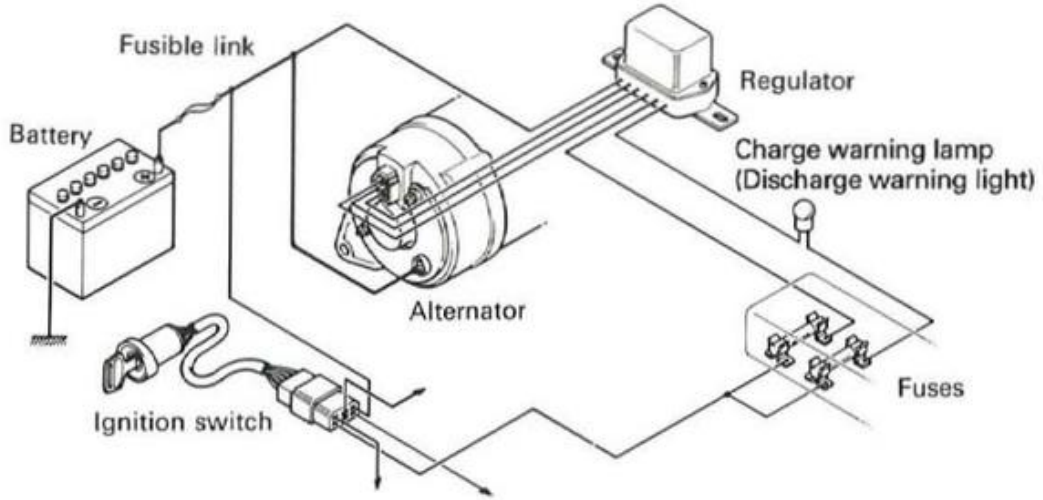
In order to charge the battery in a stable manner, without being affected by the temperature of the battery, it is necessary to vary the voltage in accordance with the temperature.

When the battery's temperature rises, the electrolyte in it reacts more actively, and reduces the battery's internal resistance. For this reason, if the same voltage as that used at lower temperatures is applied at a high temperature, excess amperage will flow to the battery, possibly overcharging the battery.

Conversely, when the battery's temperature falls, its internal resistance increases, thus slowing the flow of the electrical current.

CHARGING SYSTEM

WITH TWO-POINT TYPE REGULATOR

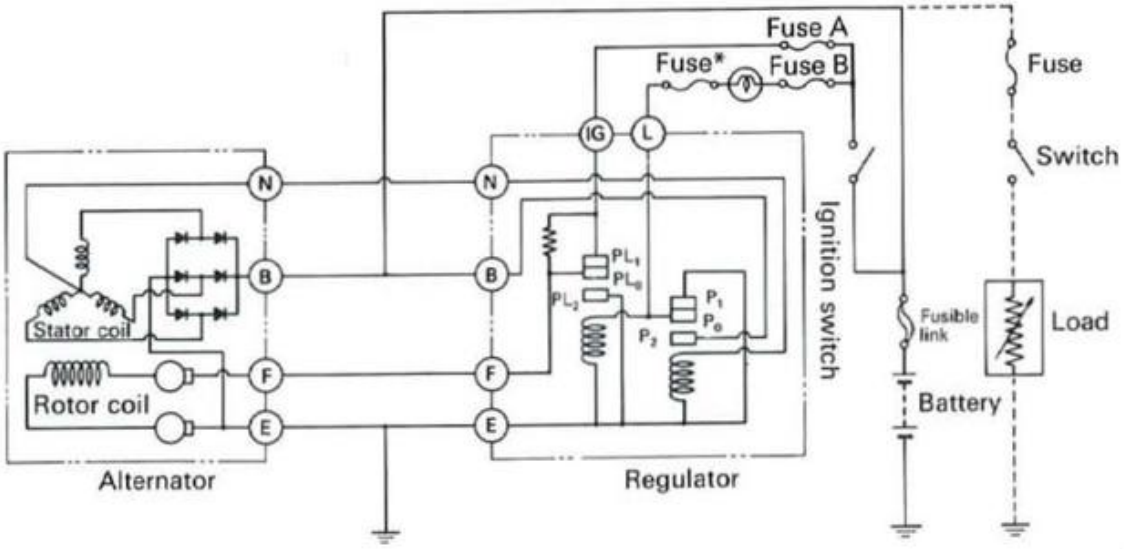


OHP 24

This is a circuit diagram for a charging system employing a two-point regulator.

The power required for the alternator rotor to produce magnetic flux is supplied from terminal F. This power (current) is controlled (increased or decreased) by the regulator in accordance with terminal B voltage. The current produced by the stator of the alternator is supplied from terminal B, and is used to resupply the loads created by the headlights, wipers, radio, etc., in addition to recharging the battery. The charge warning lamp comes on when the alternator is not supplying the normal amount of current; that is, when the voltage of terminal N of the alternator is less than the specified amount.

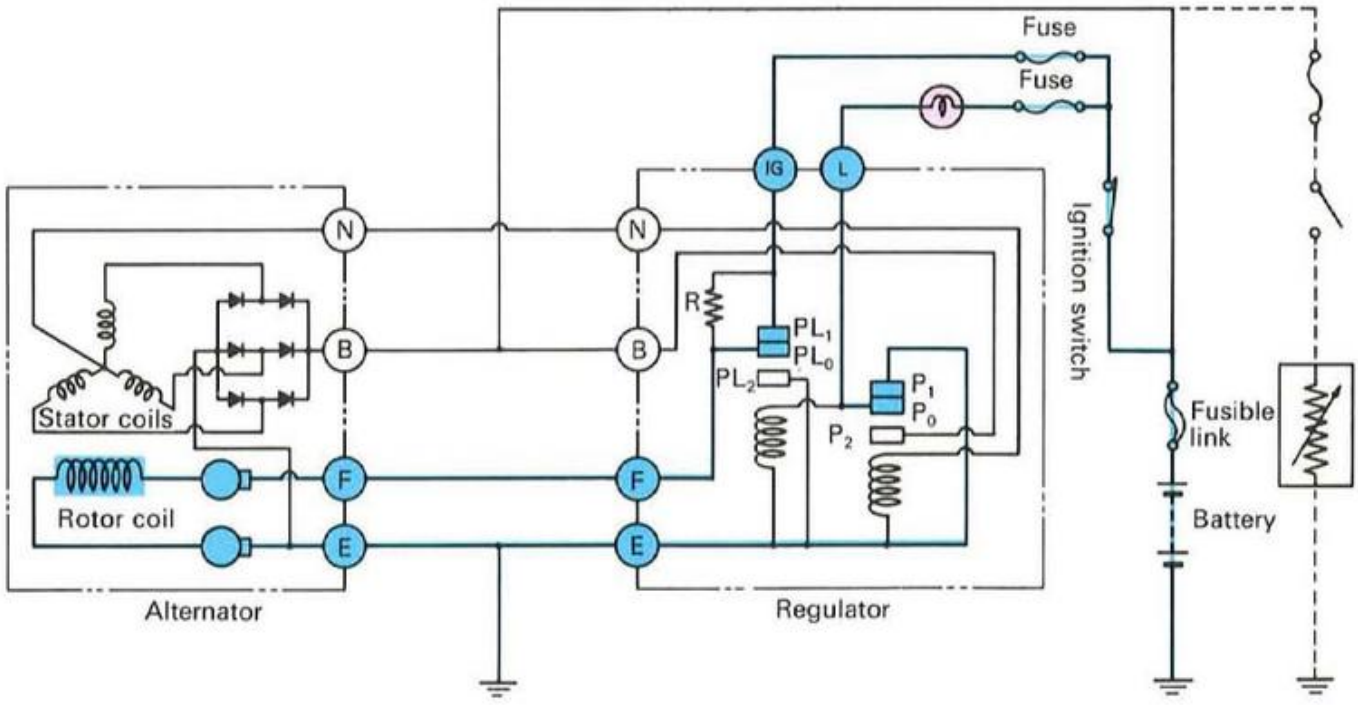
If the IG terminal fuse A blows out, current will not be supplied to the rotor and, consequently, the alternator will not generate current. The alternator will function, however, even if the charge lamp fuse B should blow out.



OHP 24

* Some models only

1. IGNITION SWITCH ON, ENGINE STOPPED



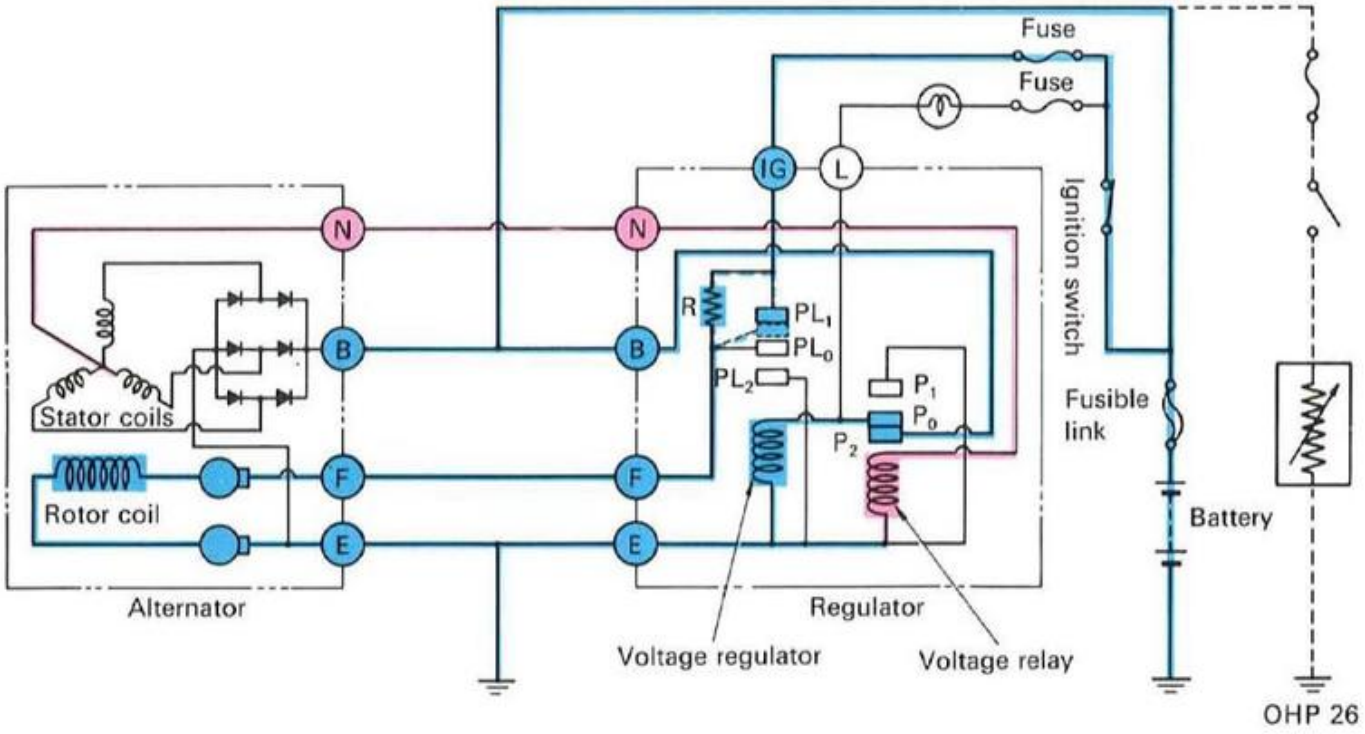
OHP 25

When the ignition switch is turned to ON, field current from the battery flows to the rotor and excites the rotor coil. At the same time, battery current also flows to the charge warning lamp and the lamp comes on.

① Battery (+) Terminal → Fusible Link → Ignition Switch → Fuse → Regulator Terminal IG →
Points PL_1 → Points PL_0 → Regulator Terminal F → Alternator Terminal F → Brushe →
Slip Ring → Rotor Coil → Slip Ring → Brushe → Alternator Terminal E → Ground
(Field Current)

② Battery (+) Terminal → Fusible Link → Ignition Switch → Fuse → Charge Warning Lamp →
Regulator Terminal L → Point P_0 → Point P_1 → Regulator Terminal E → Ground
(Charge Warning Lamp Current)

2. ENGINE OPERATING; LOW SPEED TO MIDDLE SPEED



After the engine is started and the rotor is turning, voltage is generated in the stator coils, and neutral voltage is applied to the voltage relay so the charge warning lamp goes out. At the same time, output voltage is acting on the voltage regulator. Field current to the rotor is controlled (increased or decreased) in accordance with the output voltage acting on the voltage regulator. Thus, depending on the condition of point PL_0, the field current either passes through or does not pass through the resistor (R).

NOTE

When moving point P_0 of the voltage relay makes contact with point P_2, equal voltage is applied to the circuit before and after the charge warning lamp so current will not flow to the lamp and it will not light up.

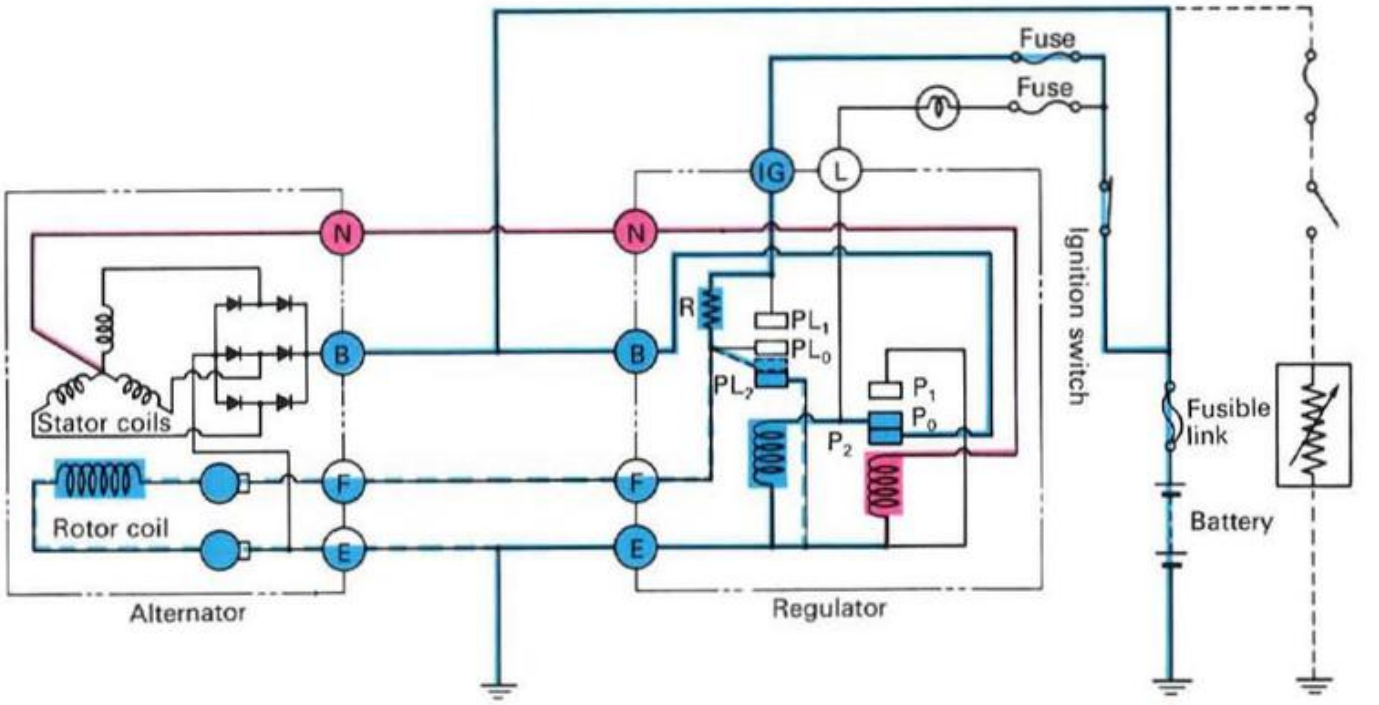
① Alternator Terminal N → Regulator Terminal N → Magnet Coil of Voltage Relay → Regulator Terminal E → Ground (Neutral Voltage)

② Alternator Terminal B → Regulator Terminal B → Point P_2 → Point P_0 → Magnetic Coil of Voltage Regulator → Regulator Terminal E → Ground (Output Voltage)

③ Alternator Terminal B → Ignition Switch → Fuse → Regulator Terminal IG → Point PL_1 → Point PL_0 → Regulator Terminal F → Alternator Terminal F
or
Resistor R → Regulator Terminal F → Alternator Terminal F
Rotor Coil → Alternator Terminal E → Ground (Field Current)

④ Alternator Terminal B → Battery and/or Load → Ground (Output Current)

3. ENGINE OPERATING; MIDDLE SPEED TO HIGH SPEED



OHP 27

As engine rpm increases, the voltage generated by the stator coil rises, and the pulling force of the magnetic coil (in the voltage regulator) becomes stronger. With a stronger pulling force, field current to the rotor will flow intermittently. In other words, moving point PL_0 of the voltage regulator intermittently makes contact with point PL_2.

NOTE

When moving point PL_0 of the regulator makes contact with point PL_2, field current is terminated. However, point P_0 of the voltage relay will not move away from point P_2 because neutral voltage is maintained in the residual flux of the rotor.

① Alternator Terminal N → Regulator Terminal N → Magnetic Coil of Voltage Relay →
Regulator Terminal E → Ground (Neutral Voltage)

② Alternator Terminal B → Regulator Terminal B → Point P_2 → Point P_0 → Magnetic Coil of Voltage Regulator → Regulator Terminal E → Ground (Output Voltage)

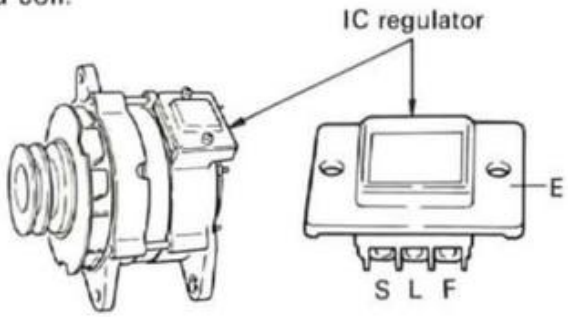
③ Alternator Terminal B → Ignition Switch → Fuse → Regulator Terminal IG →
→ Resistor R → Regulator Terminal F → Alternator Terminal F → Rotor Coil →
or
→ Point PL_0 → Point PL_2 → Ground (No Field Current)
Alternator Terminal E → Ground (Field Current)

④ Alternator Terminal B → Battery and/or Load → Ground (Output Current)

WITH A-TYPE IC REGULATOR

This type of alternator is a field-diodes exciting alternator with neutral point diodes, and the IC regulator with which it is provided is the basic A-type regulator. (This type of IC regulator is not much used at present.)
The charge lamp relay is the open/close (always open) point type.

The A-type IC regulator is a solid-state device which consists of two transistors, three resistors and two diodes. The function of the regulator is to keep the output voltage of the alternator within a range of specified values. This is performed by controlling the field current flowing through the field coil.

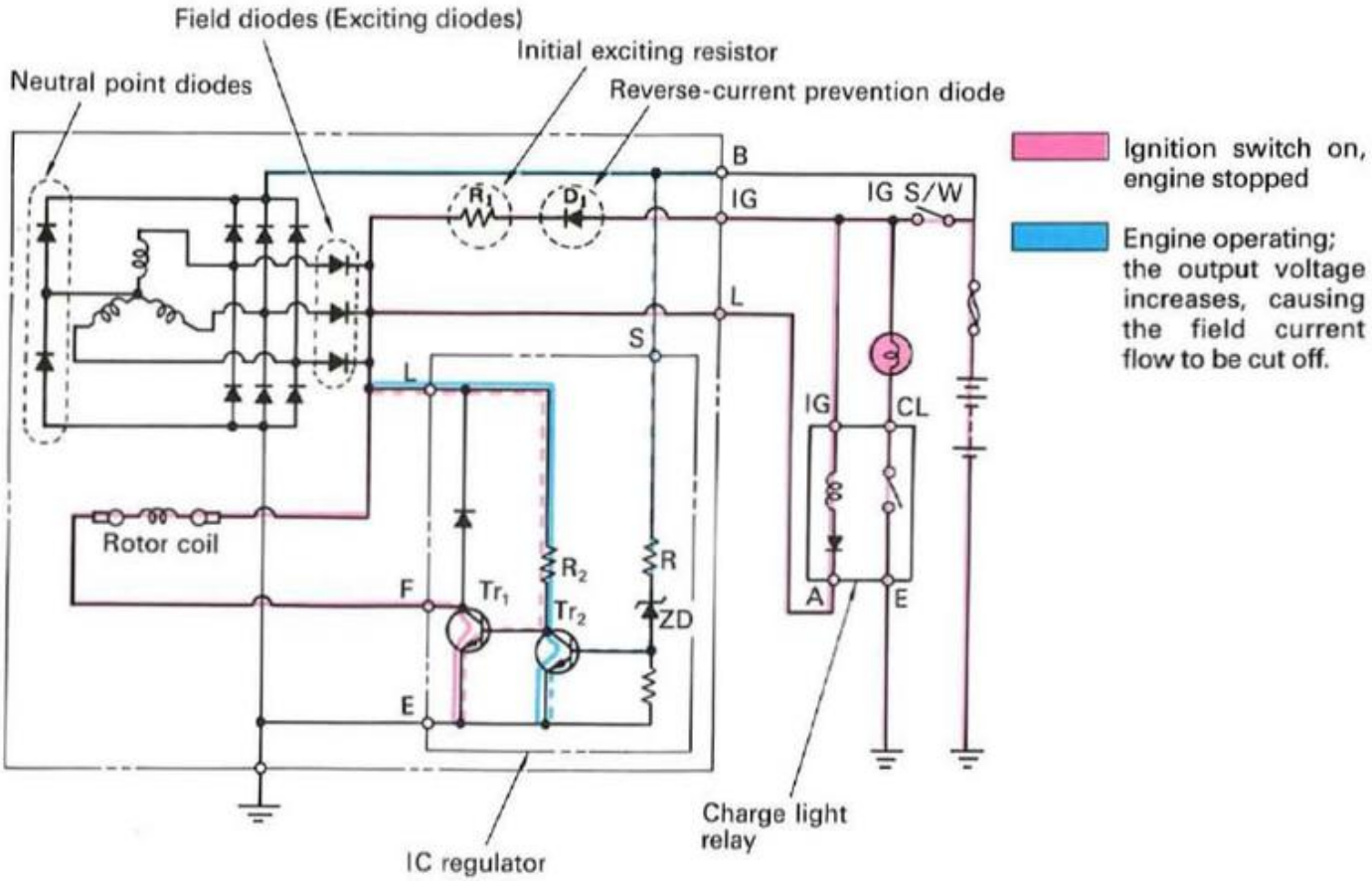


Field Current Control

Field current is controlled by interrupting the ground side (terminal F) of the rotor coil by means of Tr_1. When Tr_1 turns on and the ground circuit is closed, exciting current flows through the rotor coil. When the ground circuit is opened, exciting current ceases to flow through the rotor coil.

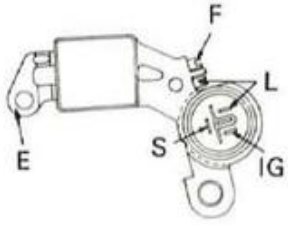
Output Voltage Sensing

Alternator output voltage is applied to the Zener diode (ZD) through a resistor (R). If the output voltage is higher than a pre-determined voltage, the Zener diode allows a signal to pass to Tr_2. This signal interrupts the rotor coil ground circuit via Tr_2 and Tr_1.



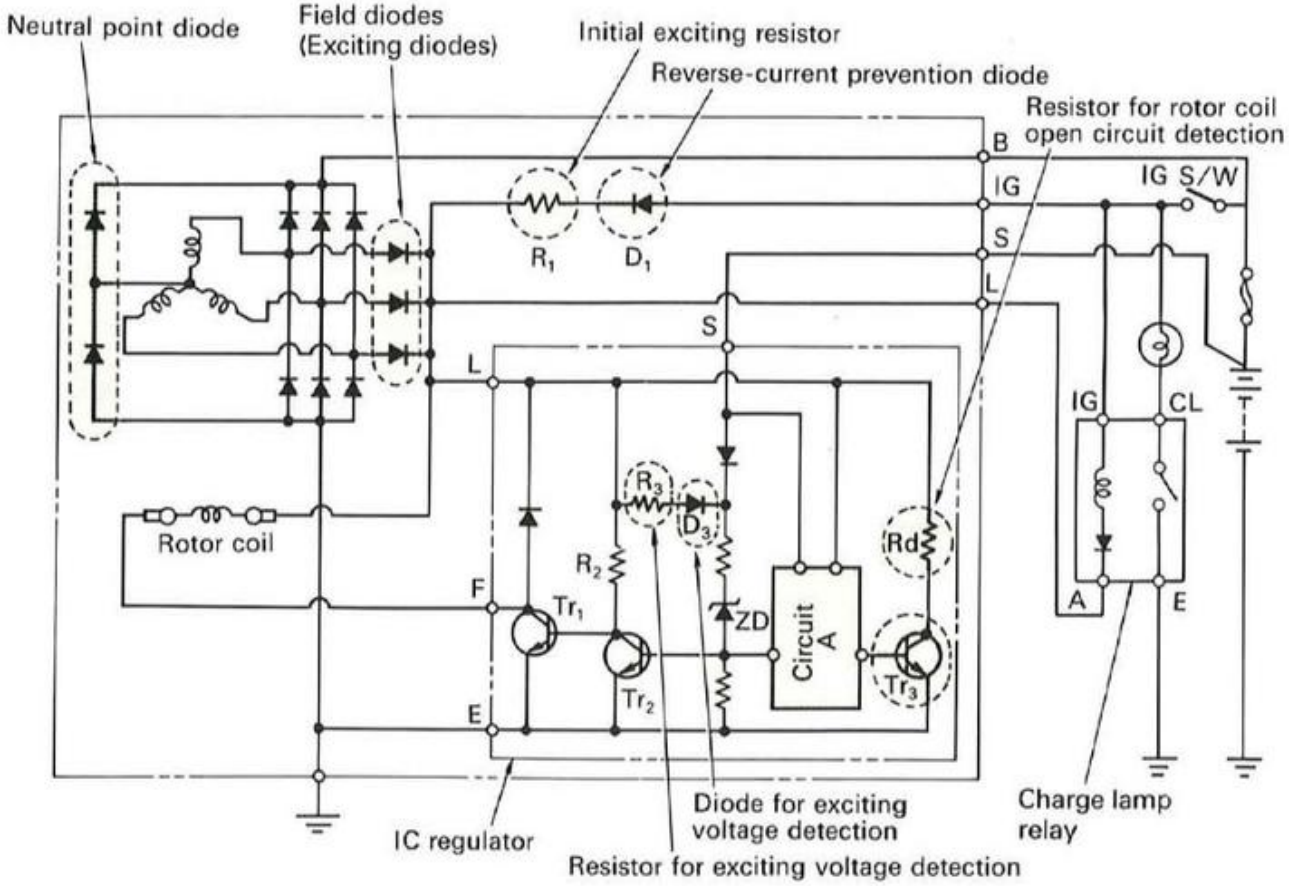
WITH B-TYPE IC REGULATOR

This is a field-diodes exciting alternator with neutral point diodes. The B-type IC regulator, which is an improved version of the A-type, is used.
For the charge lamp relay, the open/close point type is described, since it is generally used.



The B-type IC regulator is based on the A-type IC regulator in terms of its circuitry, but is different in the following points:

- While the A-type IC regulator detected the voltage at terminal B of the alternator to regulate voltage, the B-type detects the voltage at the battery terminal by way of terminal S, thus providing more accurate voltage regulation.
- An open circuit in the rotor coil is detected via circuit A and the resistor (Rd), turning on the discharge warning light.



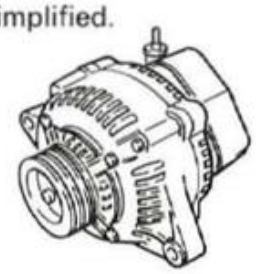
- If terminal S of the alternator becomes detached, circuit A interrupts the current that flows to the rotor coil, thus stopping the generation of electricity. At the same time, it turns on the discharge warning light.
- If terminal B of the alternator becomes detached, the resistor (R3) and diode (D3) act to limit the current that flows to the rotor coil in order to protect the alternator and regulator from excess voltage.

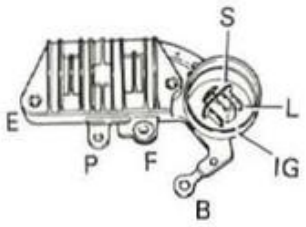
WITH M-TYPE IC REGULATOR

The alternator is a compact alternator with neutral point diodes. The difference between it and the alternator with a B-type IC regulator is that the three field diodes and initial exciting resistor are eliminated, and the IC regulator is made to control the exciting current.

Of the various types of IC regulators that are used, this section will describe the basic, multiple-function M-type regulator. Most present-day Toyotas use the M-type regulator.

The M-type IC regulator consists of a hybrid IC having a built-in monolithic integrated circuit (MIC). The M-type differs from the B type in that the IC functions as a rotor coil open-circuit detector and for charge lamp warning. Due to the elimination of the field diodes and initial exciting resistor, the charging system is somewhat simplified.



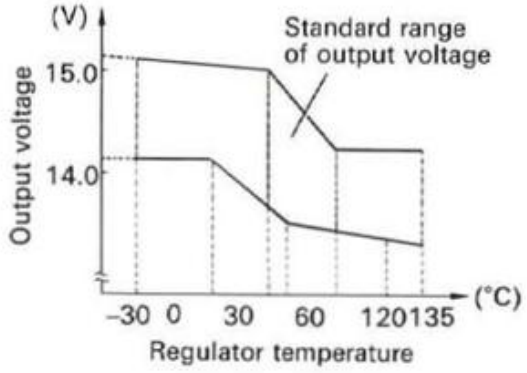


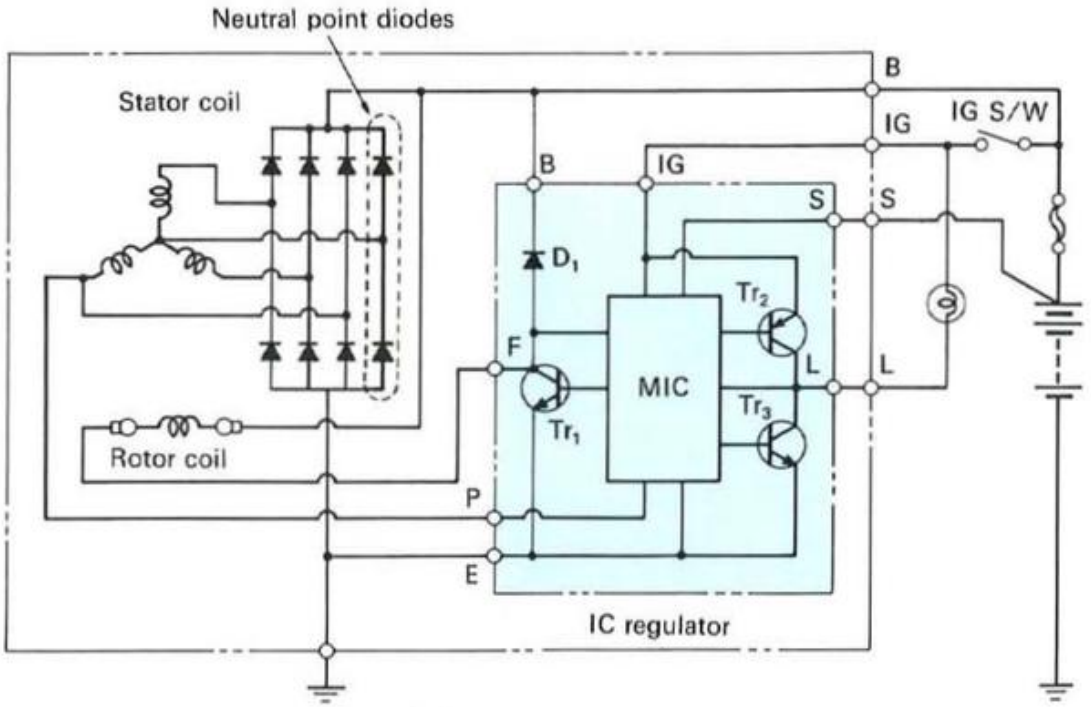
If any of the following troubles occurs, the M-type IC regulator causes the charge warning lamp to go on:

- Open in rotor coil circuitry.
- Open in regulator sensor (terminal S) circuitry.
- Voltage at terminals drop below 13 V.

1. TEMPERATURE CHARACTERISTICS

The temperature characteristics of this regulator are different from those of the A- and B-types, being in step form. This improves the charging performance.



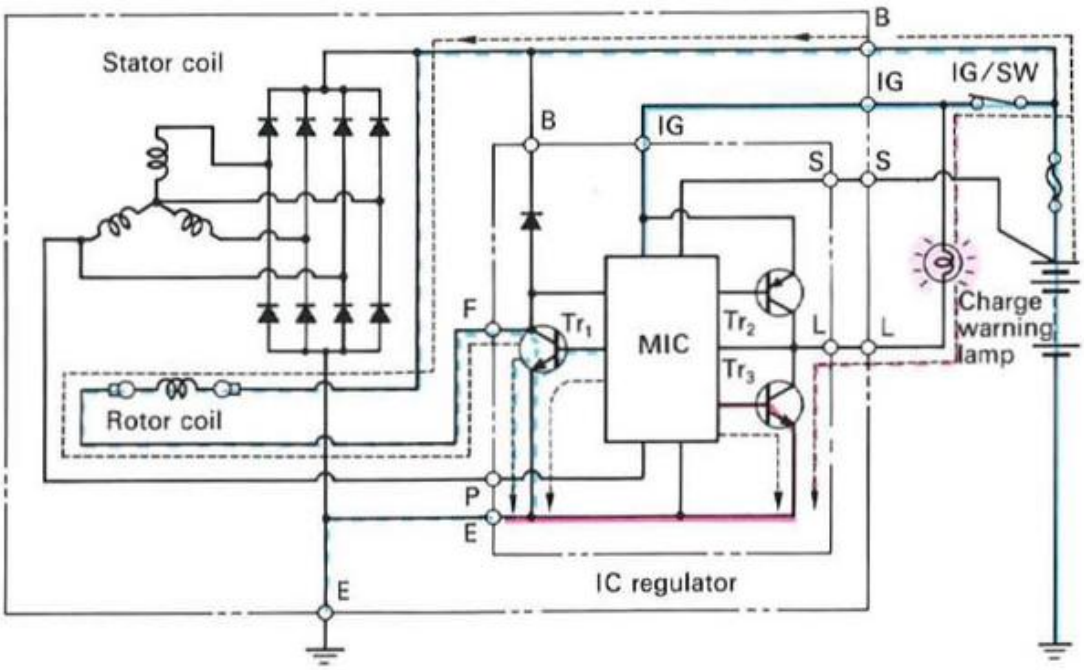


2. IGNITION SWITCH ON, ENGINE STOPPED

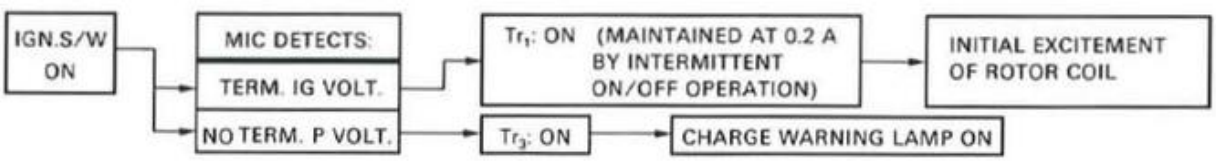
Turning the ignition switch ON applies battery voltage to terminal IG of the IC regulator. This battery voltage is detected by the MIC and Tr_1 is turned on, causing the initial exciting current to flow to the rotor coil via the battery and terminal B. In order to reduce the battery discharge current when the ignition switch is on at this time, the MIC keeps the exciting current to a value as small as about 0.2 A by intermittently turning Tr_1 on and off.

Charge Warning Lamp

Since generation of electricity has not yet begun, terminal P voltage is zero. This is detected by the MIC, which turns Tr_2 off, and Tr_3 on, causing the charge warning lamp to come on.



OHP 29

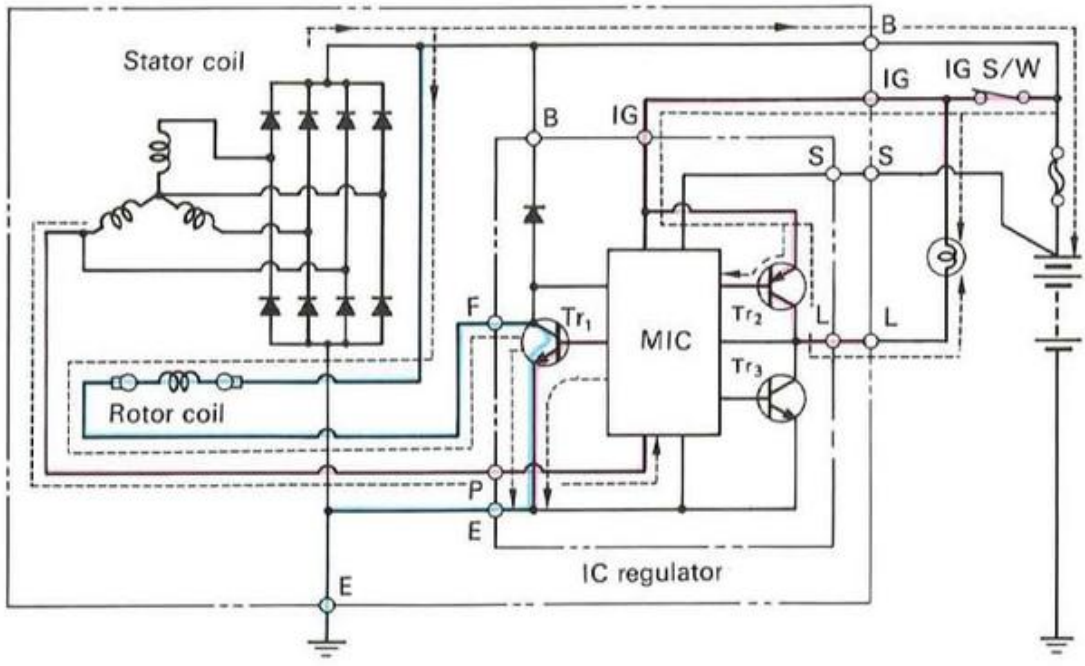


3. GENERATION OF CURRENT BY ALTERNATOR (Less than Standard Voltage)

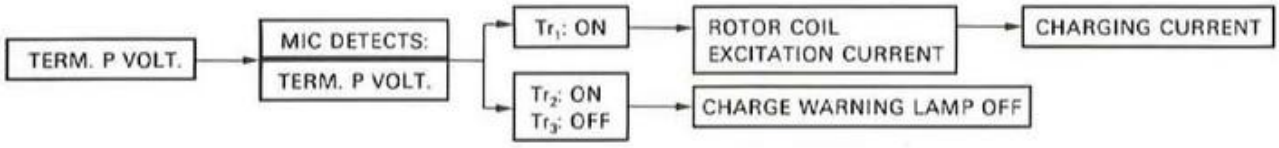
When the alternator starts generating current and terminal P voltage rises, the MIC switches Tr_1 from an intermittent on–off state to a continuous on state, causing sufficient exciting current to be supplied by the battery to the rotor coil. Therefore, the generated current increases suddenly.

Charge Warning Lamp

When terminal P voltage rises, the MIC turns Tr_3 off and Tr_2 on. Since there is then no potential difference between both ends of the charge warning lamp, the lamp goes out.



OHP 30



REFERENCE

Vehicles with a carburetor use the terminal L voltage to operate the automatic choke. Therefore, after the engine is started and the alternator starts generating, Tr_2 turns on and the battery voltage will be applied to terminal L.

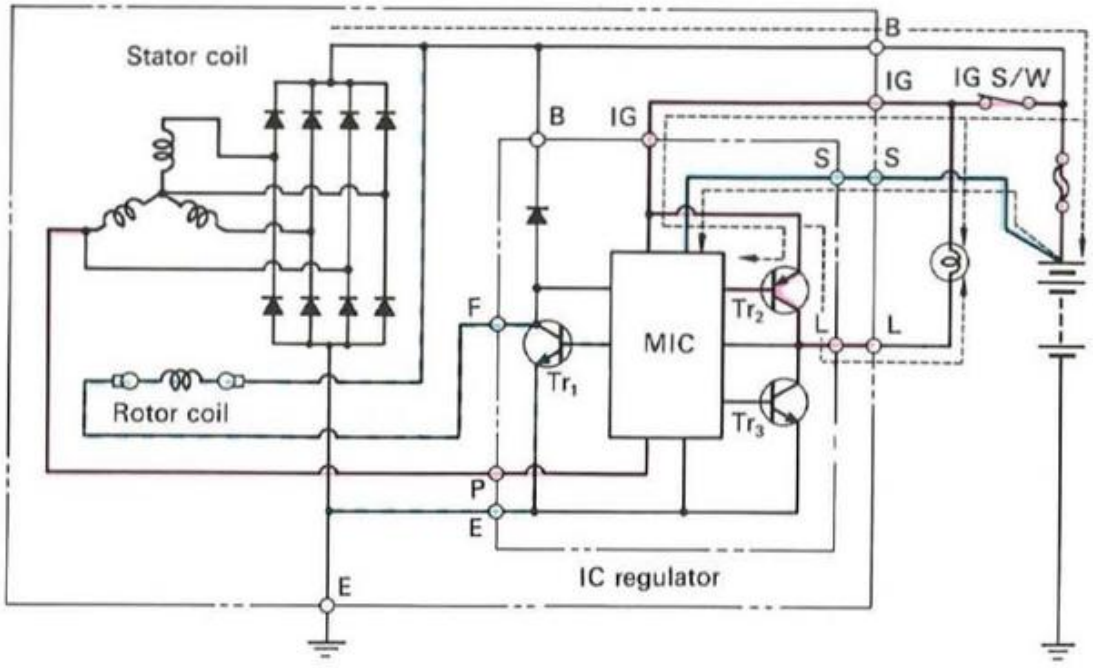
Because vehicles with EFI do not use an automatic choke, they do not need Tr_2; they only use Tr_3 to control the charge warning lamp.

4. GENERATION OF CURRENT BY ALTERNATOR (Standard Voltage Reached)

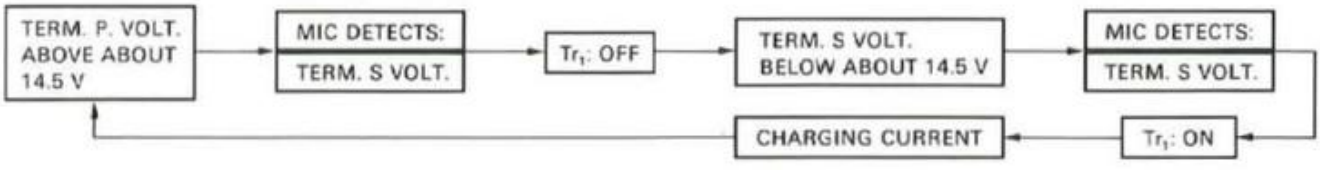
When Tr_1 stays on and terminal S voltage reaches the standard voltage, this condition is detected by the MIC and Tr_1 is turned off.
When terminal S voltage drops below the standard range, the MIC detects this drop and turns Tr_1 on again. By the repetition of this process, S-terminal voltage is kept at the standard voltage.

Charge Warning Lamp

Since P-terminal voltage is high, the MIC keeps Tr_3 off and Tr_2 on, so the charge warning lamp remains un-lighted.



OHP 31



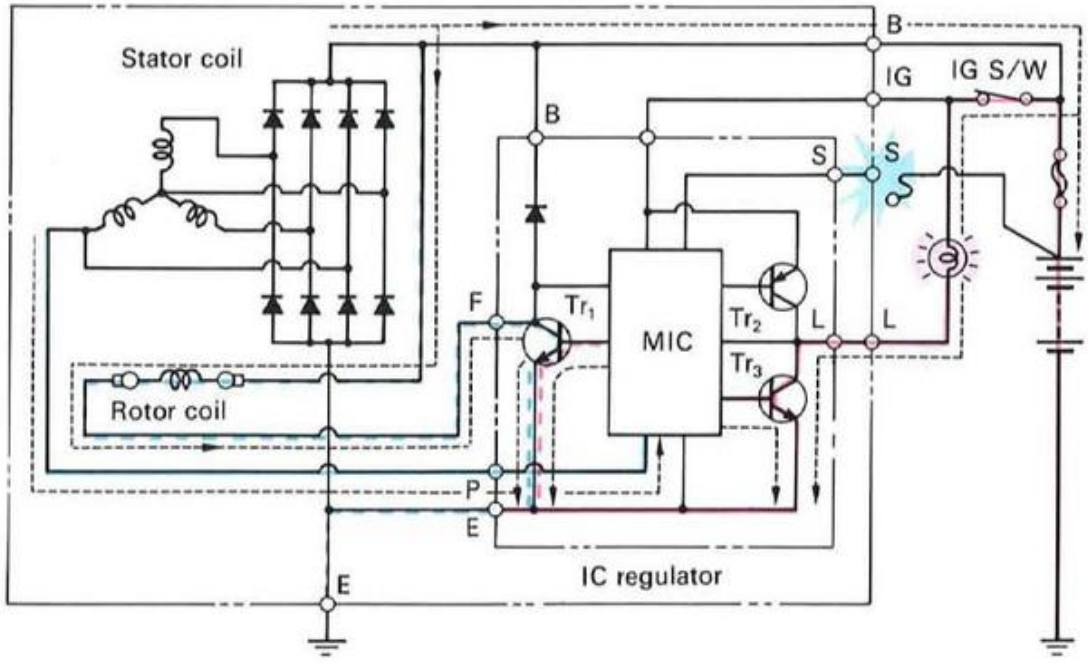
5. OPEN IN REGULATOR SENSOR (Terminal S) CIRCUITRY

If an open develops in the regulator sensor circuitry while the alternator is running, "no input from terminal S" is detected by the MIC, and Tr_1 is turned on and off to maintain the terminal P voltage between 13.3 and 16.3 V. As a result, terminal B will be maintained at approximately the same voltage.

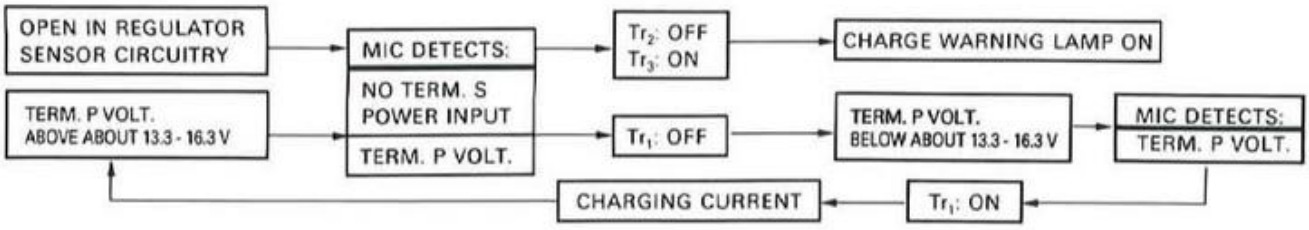
This prevents the output voltage from rising unusually high, thus protecting the alternator, IC regulator and other electrical components.

Charge Warning Lamp

When the MIC detects "no input from terminal S" it turns Tr_2 off and Tr_3 on, causing the charge warning lamp to come on.



OHP 32

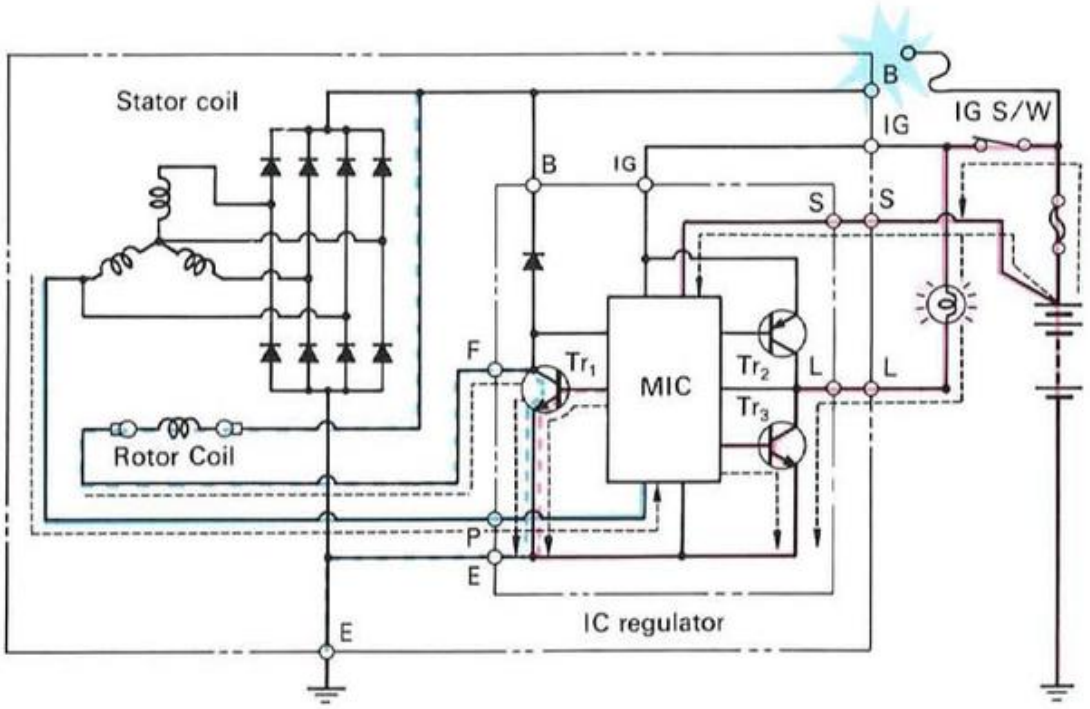


6. OPEN IN ALTERNATOR TERMINAL B CIRCUITRY

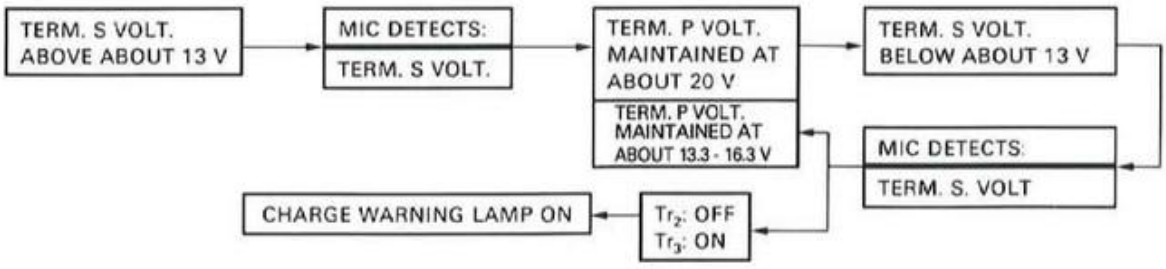
Charging of the battery is not performed, so the MIC keeps terminal B voltage to 20 volts on the basis of terminal P voltage by turning Tr_1 on and off. This prevents the output voltage from rising unusually high, thus protecting the alternator and IC regulator.

Charge Warning Lamp

If charging of the battery is not continuously performed, the battery voltage drops in the course of time. When terminal S voltage (battery voltage) drops below 13 volts, it is detected by the MIC, which turns Tr_2 off and Tr_3 on, causing the charge warning lamp to come on.

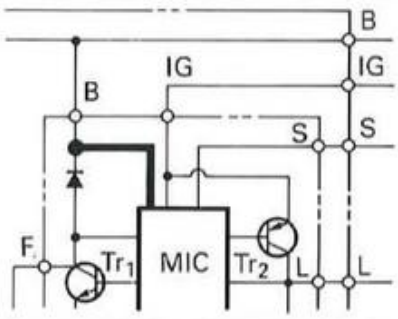


OHP 33



REFERENCE

On some types of IC regulators, terminal B voltage is incorporated in the MIC inside the IC regulator. With this type of IC regulator, in case of an open circuit at terminal S or terminal B, the MIC will regulate the voltage at terminal B, instead of terminal P, to be approximately 14V.

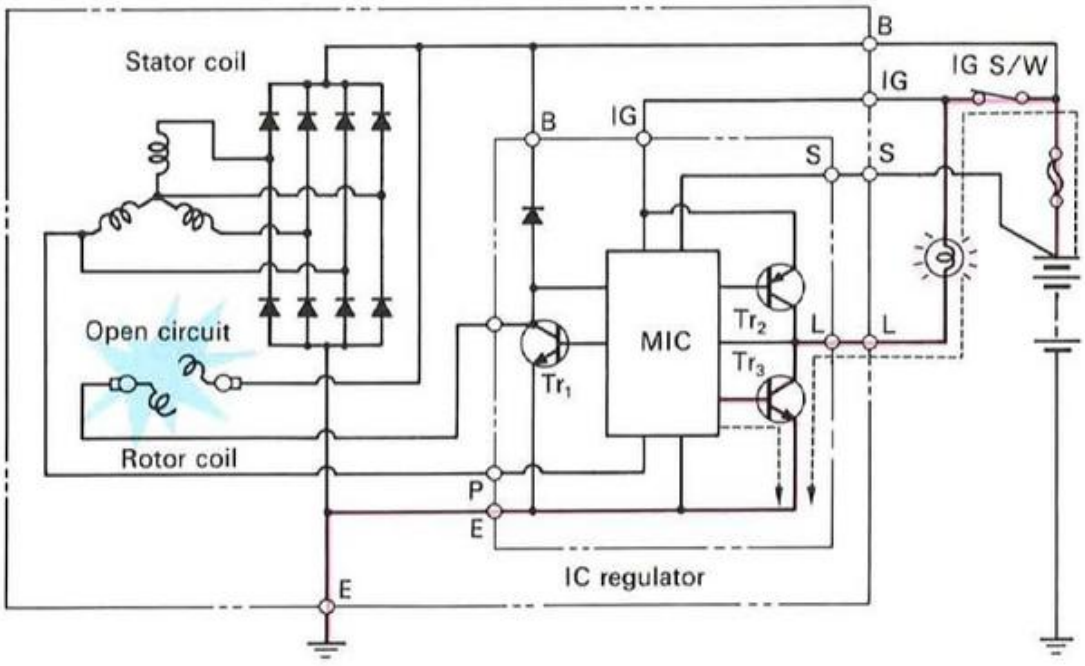


7. OPEN IN ROTOR COIL CIRCUITRY

If an open circuit develops in the rotor coil circuitry, generation of electricity stops. Also, terminal P output voltage becomes zero.

Charge Warning Lamp

When generation of electricity stops and terminal P voltage becomes zero, this condition is detected by the MIC, which turns Tr_2 off and Tr_3 on.



OHP 34

TROUBLESHOOTING

Normally, the driver will first become aware that something is wrong with the charging system when the charge warning lamp comes on. In addition, it is often discovered that the charging system is abnormal when the engine cannot be cranked due to a weak battery or when the luminosity of the headlights changes.

In any case, whenever it is suspected that the charging system is faulty, the cause must be located and the faulty component repaired or replaced.

A weak (undercharged) battery is often due to an abnormality in the battery itself, such as insufficient electrolyte in the cells or deteriorated plates. Or, it could be caused by insufficient tension in the drive belt, which is causing the belt to slip.

However, there are also cases when problems are caused by the manner in which the vehicle is used and not by a faulty battery or charging system. For example, such problems could occur if the vehicle is used for short-distance trips only. In such a case, the battery current is consummed by frequent engine starting and, because the trips are short, the battery doesn't have time to fully recharge. This would be especially true if the vehicle is used in this manner at night because almost all current generated by the alternator is supplied to the headlights, resulting in insufficent recharging of the battery.

When troubleshooting the charging system, it is essential to have a good comprehension of the problem and to confirm its symptoms.

CLASSIFICATION OF CHARGING SYSTEM PROBLEMS

For charging systems utilizing a charge warning lamp, problems can be classified into the following four categories:

1. **Abnormal operation of charge warning lamp (discharge warning light)**
   a. Lamp does not come on when ignition switch is turned to ON position.
   b. Lamp does not go out after engine starts.
   c. Lamp lights faintly while engine is running.
   d. Lamp sometimes comes on while engine is running.
2. **Weak (discharged) battery**
   a. Cannot crank engine with starter.
   b. Headlights are dim
3. **Overcharged battery**
   Battery electrolyte is used up quickly.
4. **Abnormal noise**
   a. Abnormal noise from alternator.
   b. Static in radio.

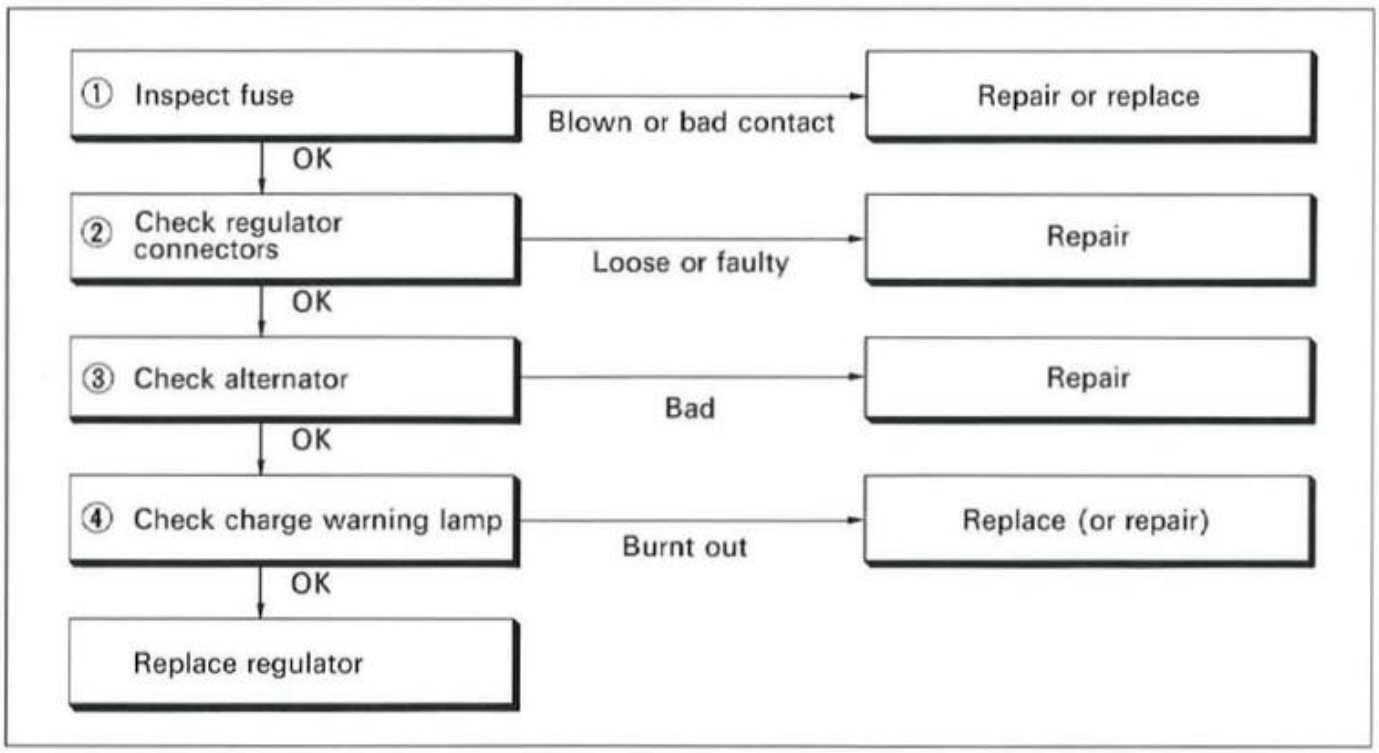
ALTERNATOR WITH POINT TYPE REGULATOR

Once the symptoms of the problem are confirmed, the cause must be determined. There are various methods doing this but the quickest and most accurate method should be used. In this respect, it is very important that the related areas be checked in correct order.

For example, when trying to locate the cause of symptom, you should check each of the main points as follows:

1. Abnormal Operation of Charge Warning Lamp (Discharge Warning Light)

a. Charge warning lamp does not come on when ignition switch turned to ON.



① Check for a blown fuse or faulty contact in the charge warning lamp circuit.

② Check for loose or faulty regulator connectors.

③ Check for a short-circuit in the positive diodes of the alternator.

- If the charge warning lamp lights when the three-pin connector of the alternator is disconnected, the diodes are short-circuited. (Even if only one positive diode is short-circuited, battery current will flow from terminal B to terminal N via the bad diode. This current will cause the voltage relay to operate, and the moving point will be pulled so the charge warning lamp will not light).

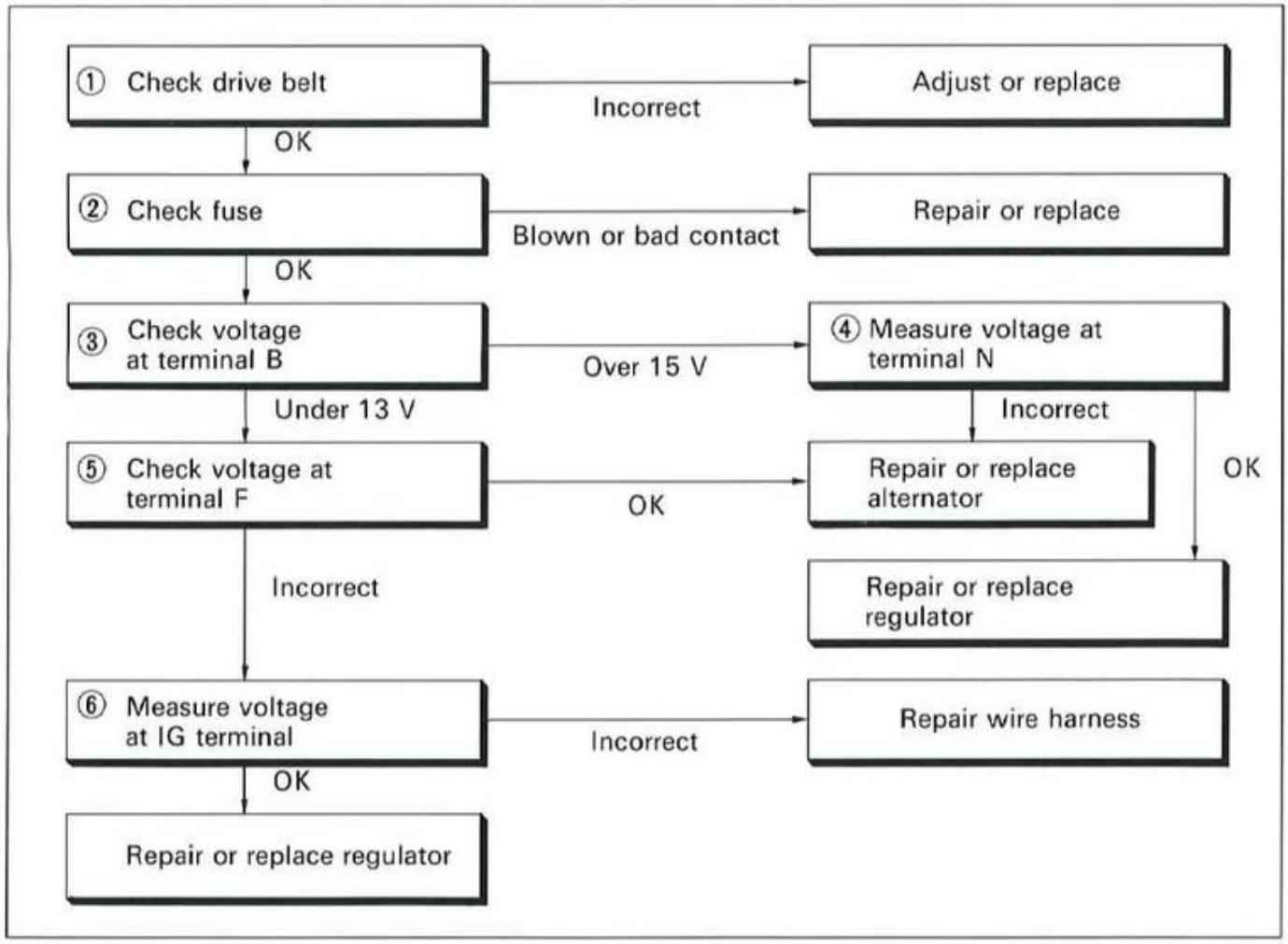
④ Check for burnt out bulb of charge warning lamp.

- With the regulator connected, ground terminal L of the connector. If the charge warning lamp comes on, the regulator is bad. If the charge warning lamp does not come on, either a burnt out bulb or a faulty wire harness is indicated.

NOTE: The layout of the wiring harness depends on the vehicle, but a check should be made of all connectors between the ignition switch and the regulator.

b. Charge warning lamp does not go out after engine starts.

This symptom indicates that the alternator is either not generating electricity or is overcharging.



① Check the drive belt for damage or slipping.

② Check if the fuse connected to the regulator's IG terminal is blown or loose.

③ Measure output voltage at terminal B of alternator.

- If voltage is less than specified (13.8 – 14.8 V), the alternator is not generating electricity. If voltage is in excess of this specification, the alternator is overcharging.

  If the voltage relay is not operating, voltage is not being controlled by the voltage regulator, resulting in overcharging of the battery.

④ Measure the neutral voltage at terminal N of the regulator connector.

- Voltage indicates a broken coil in the regulator voltage relay. No voltage indicates an open in the neutral circuit of the alternator.

⑤ Measure the field voltage at terminal F of the regulator connector.

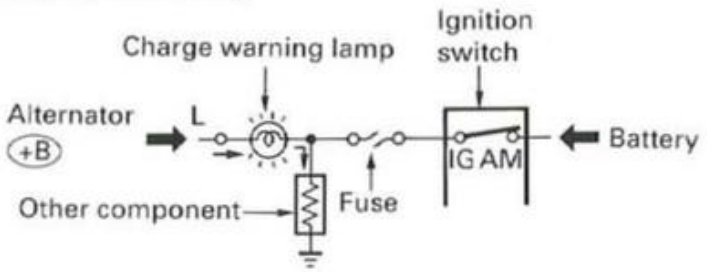
- Voltage indicates a broken coil in the rotor or faulty brush contact in the alternator. If there is no voltage, measure the voltage at the IG terminal.

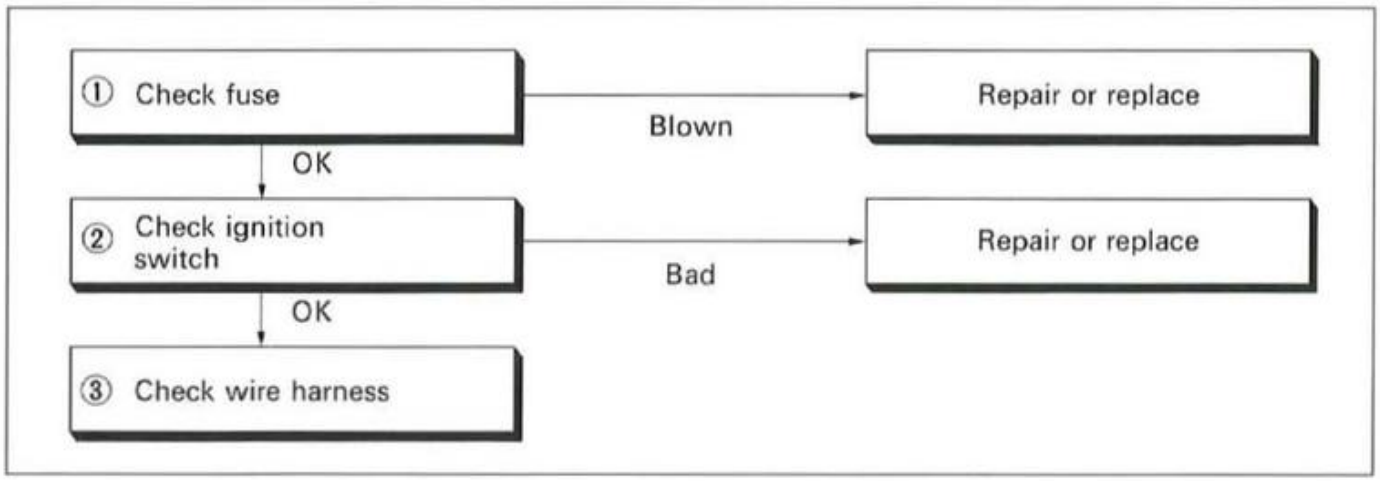
⑥ Measure the battery voltage at the IG terminal of the regulator connector.

- Voltage indicates a bad regulator. No voltage indicates damage to the wire harness between the ignition switch and regulator connector.

c. Charge warning lamp lights faintly when engine is running.

This symptom sometimes indicates that there is a reverse current from terminal L of the regulator via the charge warning lamp.





① Check the charge warning lamp circuit for a blown fuse or bad fuse contact.

- This fuse is not only for the charge warning lamp circuit but also protects other electrical components. When the ignition switch is turned to ON, current is supplied to these components. If this fuse is blown or if it is not making proper contact, current will not flow via the ignition switch. However, if the alternator is generating electricity, the voltage relay will operate and current will flow from terminal L to the components via the points and the charge warning lamp, causing the charge warning lamp to light faintly. The lamp will shine brighter at higher engine speeds because more voltage will be generated.

② Measure the internal resistance of the ignition switch.

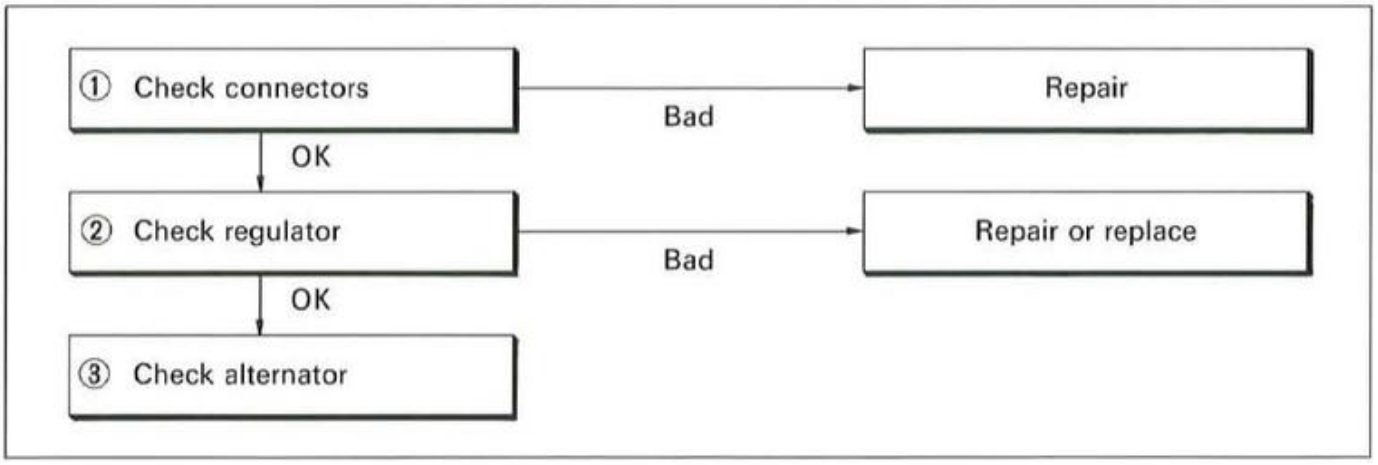
- Disconnect the ignition switch connector and, with the ignition switch ON, measure the resistance between terminals AM and IG of the connector.
  If there is much contact resistance in the ignition switch, the voltage applied to the fuse will be reduced. Therefore, as when there is a blown fuse, current from terminal L will be reversed and the charge warning lamp will shine faintly.

③ Check for faulty contact at each connector of the wire harness.

- Measure the voltage of each connector of the wire harness between the battery and the charge warning lamp circuit fuse. If voltage is unusually low, it indicates a bad contact.
  As when there is excessive resistance in the ignition switch, voltage will also be reduced if there is much resistance in the wiring harness, and current will flow in reverse from terminal L via the charge warning lamp.

d. Charge warning lamp sometimes comes on while engine is running.

This symptom sometimes indicates that the alternator is not generating.



① Check the alternator and regulator connector for loose or bad connections.
- Lightly tap the alternator and regulator connector. If the charge lamp blinks, connector contact is poor.
  If the connector terminals are not making proper contact due to vibration, the current to the terminals will be interrupted, so the alternator will not be able to generate power and the charge warning lamp will come on.

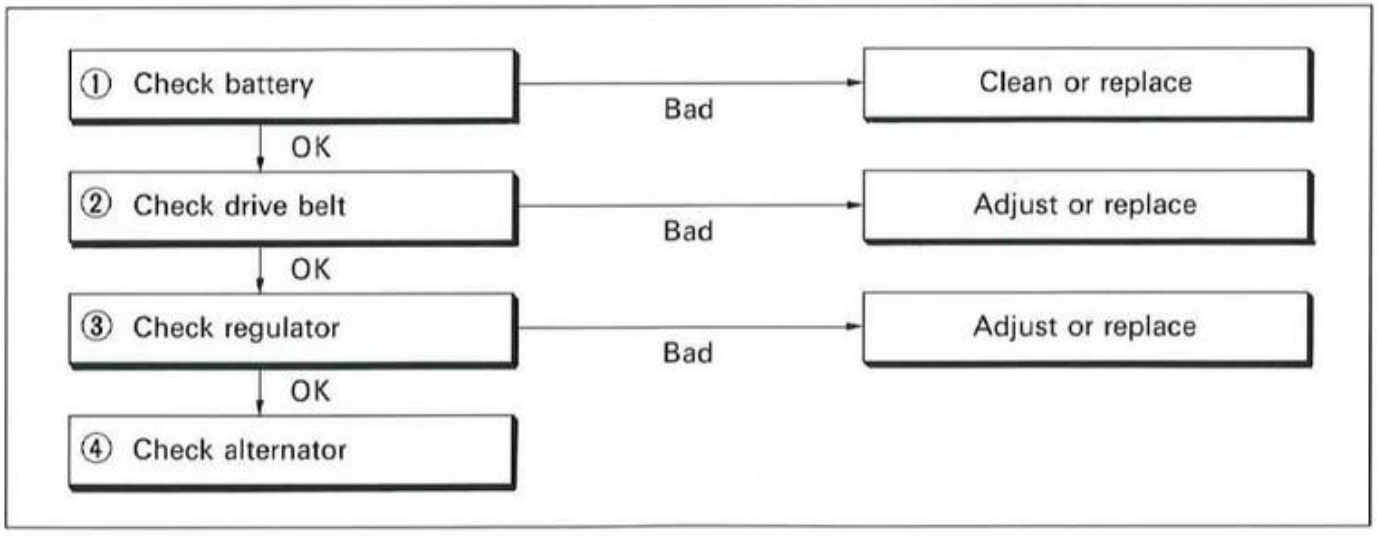
② Check the contact condition of each point of the regulator and the resistance between each terminal.
- Measure the resistance between each terminal in accordance with the procedures listed in the repair manual. In particular, check the condition of the high-speed point and the resistor.

③ Check the contact condition of the brushes.
- Disassemble the alternator in accordance with the procedures listed in the repair manual and check the brush wear and contact condition of the slip rings.
  If the brushes are worn beyond the allowable limit, spring tension will be reduced, causing poor brush contact. If this happens, field current to the rotor will be interrupted, and the alternator will not be able to generate power, causing the charge warning lamp to come on.

2. Weak (discharged) Battery

This problem will occur when the alternator is not generating sufficient current to re-charge the battery. As a result, the engine cannot be started with the starter. In addition, the headlights will be dim. However, because the alternator is still generating a little current, the charge warning lamp will go out after the engine is started.

As there are several possible reasons why the alternator is not generating enough current, it is important that proper troubleshooting procedures be followed. The first thing to do is investigate how the vehicle has been used (driving conditions). In order for the alternator to recharge the battery, it is necessary that the vehicle be driven continuously for a certain length of time. This is especially true at night because the battery will not be completely recharged if the vehicle is frequently driven for only short periods. This problem will also occur if the vehicle is equipped with several power consumming accessories. In such cases, it may be necessary to replace the alternator with one of a larger capacity.



① Check the condition of the battery.
- Check the battery terminals for dirtiness and corrosion. If necessary, add electrolyte.
  (Dirtiness or corrosion of the battery terminals will cause increased resistance to the flow of current. Also, if the battery is very old, the plates will self-discharge. In this case, it is recommended to replace the battery with a new one.)

② Check the tension of the drive belt
- Check the alternator drive belt for proper tension.
  (A loose drive belt will slip, preventing the alternator from turning fast enough to generate sufficient electricity. Even with correct belt tension, the belt may be slipping if the sides are worn. In this case, the belt should be replaced.)

③ Check the standard voltage of the regulator (alternator output voltage).
- Check that the output voltage of the alternator (voltage at terminal B) is within specification. Refer to "On-vehicle Inspection".
  (If the alternator output voltage is less than specified, there will not be sufficient voltage to recharge the battery. Under normal conditions, the battery voltage will be at least 13 V, so if the standard voltage (alternator output voltage) is not above this amount, current will not flow to the battery. Also, if output voltage is too low, current will not be able to flow to the headlights, causing them to be dim.)

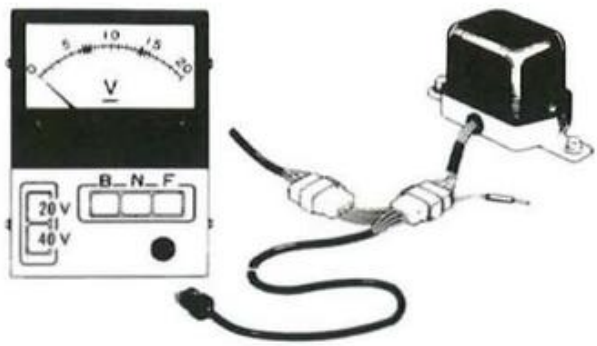
④ Check the output current of the alternator.

- Check to see whether the alternator output current is within specification. Refer to the "On-vehicle Inspection".
  (The alternator utilizes diodes for rectifying current. If there is a short or open circuit, all of the current generated by the stator coil cannot be supplied to the battery.)

REFERENCE

Of course, alternator output voltage and neutral voltage can be measured with an ordinary voltmeter, but it can be done more quickly and easily with a Toyota Alternator Checker (SST 09081-00011). With this checker, the regulator can also be checked by measuring the voltage at terminal F.

If there is no problem with the diodes, the neutral voltage at terminal N will be half of the output voltage. To perform a simple check, compare the voltage at the terminal N to the normal voltage, and if the terminal N voltage is higher, the "+" diodes can be judged faulty. If, however, judged terminal N voltage is lower, the "–" diodes can be judged faulty.



Alternator checker

3. Overcharged Battery

Battery overcharging is indicated by the necessity to frequently add battery electrolyte.
Also, headlight luminosity will change with engine rpm. This problem is caused by excessively high regulator standard voltage (alternator output voltage). If the output voltage of the alternator is greater than specified, the battery will overcharge, causing a rise in battery temperature and rapid consumption of the electrolyte.

In addition, when the engine is running at a high rpm, excessive current will flow to the headlights and they will shine brighter. In extreme cases, there will be so much current to the lamps that it will cause the bulbs to burn out.

Troubleshooting this problem involves measuring the output voltage of the alternator and checking and/or adjusting the regulator. Refer to "On-vehicle Inspection".

4. Abnormal Noise

Abnormal noise in the charging system originates with the alternator. There are two different types of noises and these must be distinguished before beginning troubleshooting:

The first type of noise is mechanical noise caused either by the drive belt slipping at the alternator pulley, or worn or damaged alternator bearings.

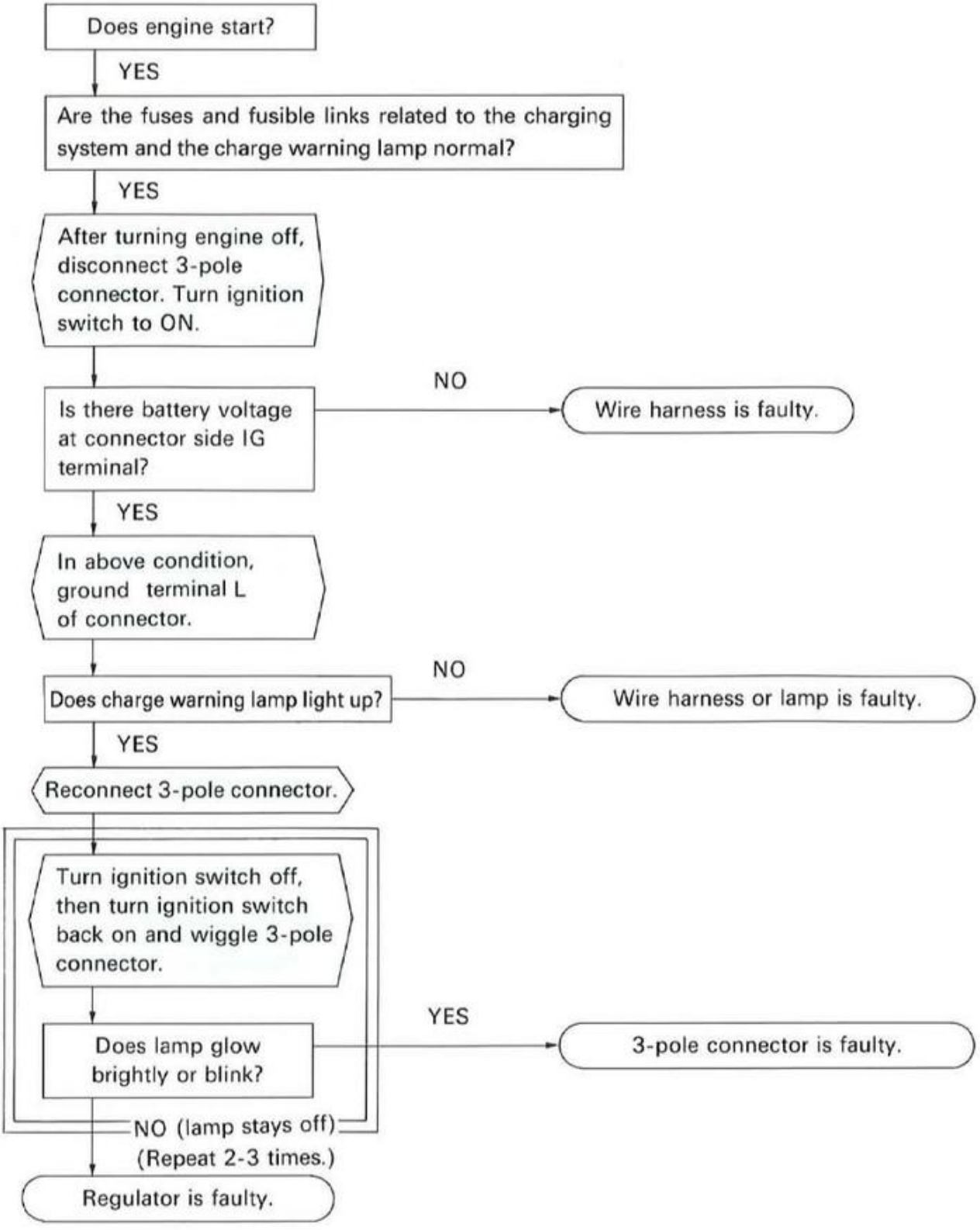
The second type is magnetic resonance, caused either by a layer short in the stator coil or faulty diodes. In the case of magnetic resonance, radio static will often be synchronized with engine rotation.

Except for drive belt noise, it is necessary to disassemble the alternator, inspect each component and repair as necessary.

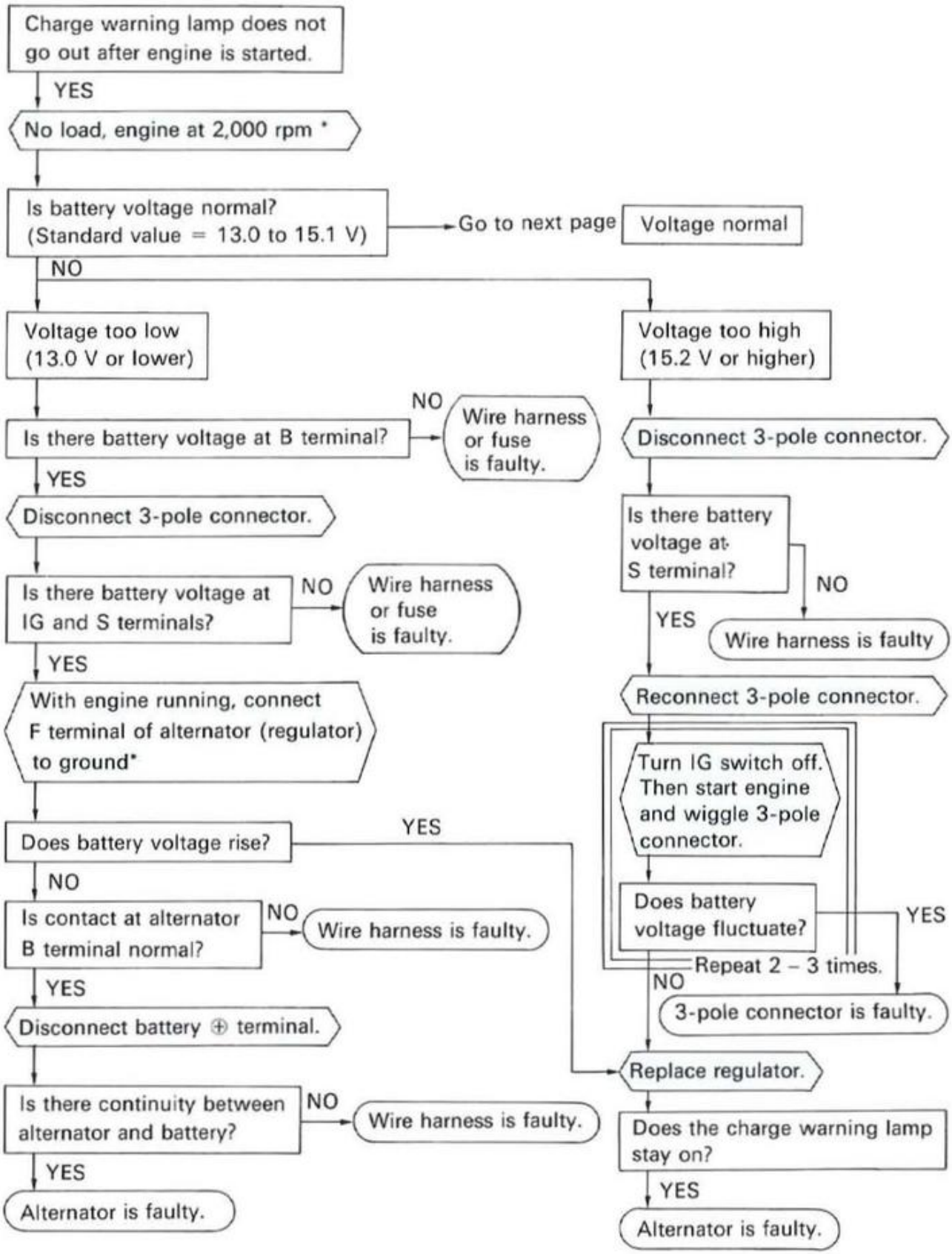
ALTERNATOR WITH M-TYPE IC REGULATOR

Before assuming that the alternator with IC regulator is faulty, always check the fuses, wire harness, and connectors first.

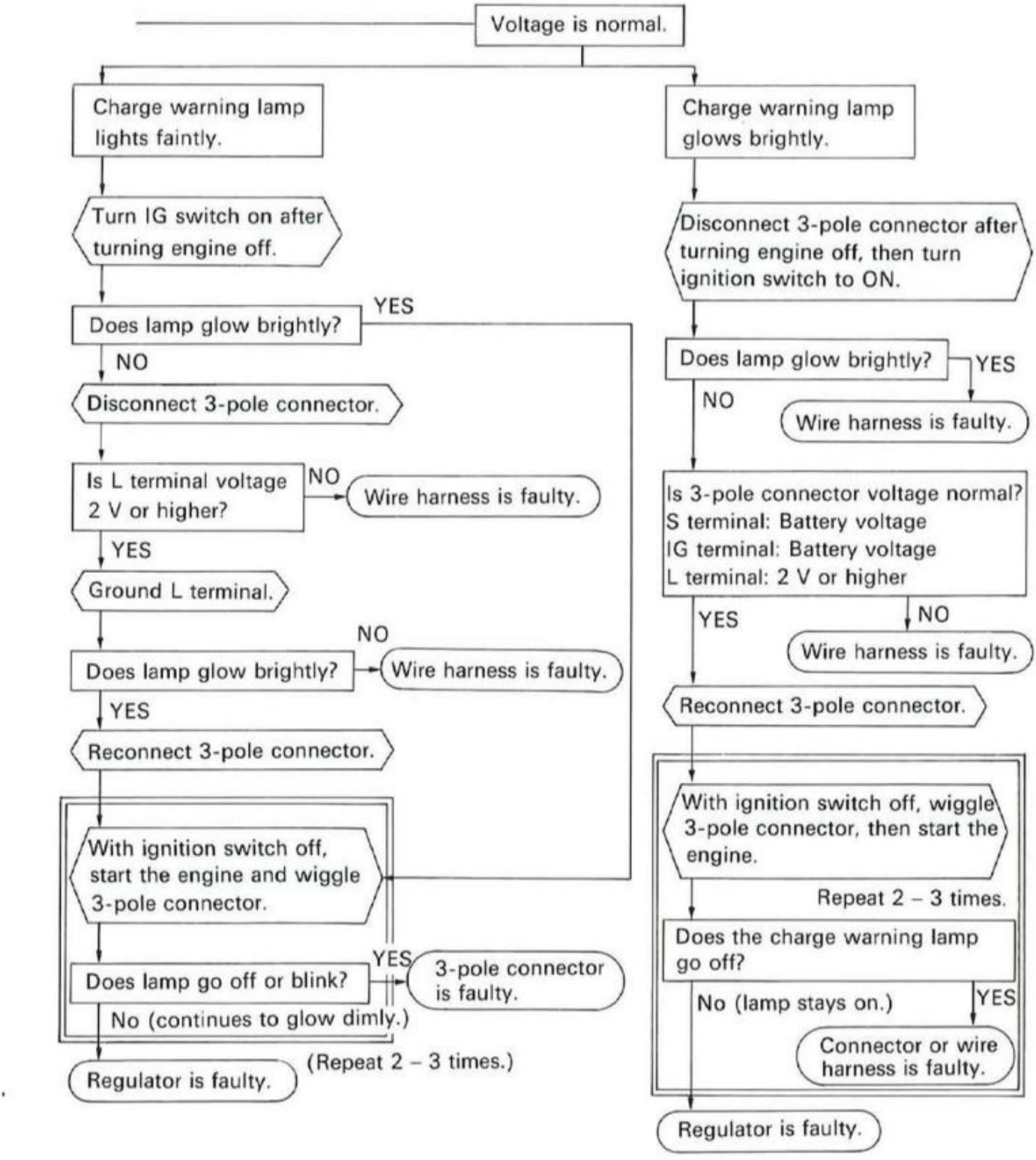
1. Charge warning lamp does not come on when ignition switched turned to ON.



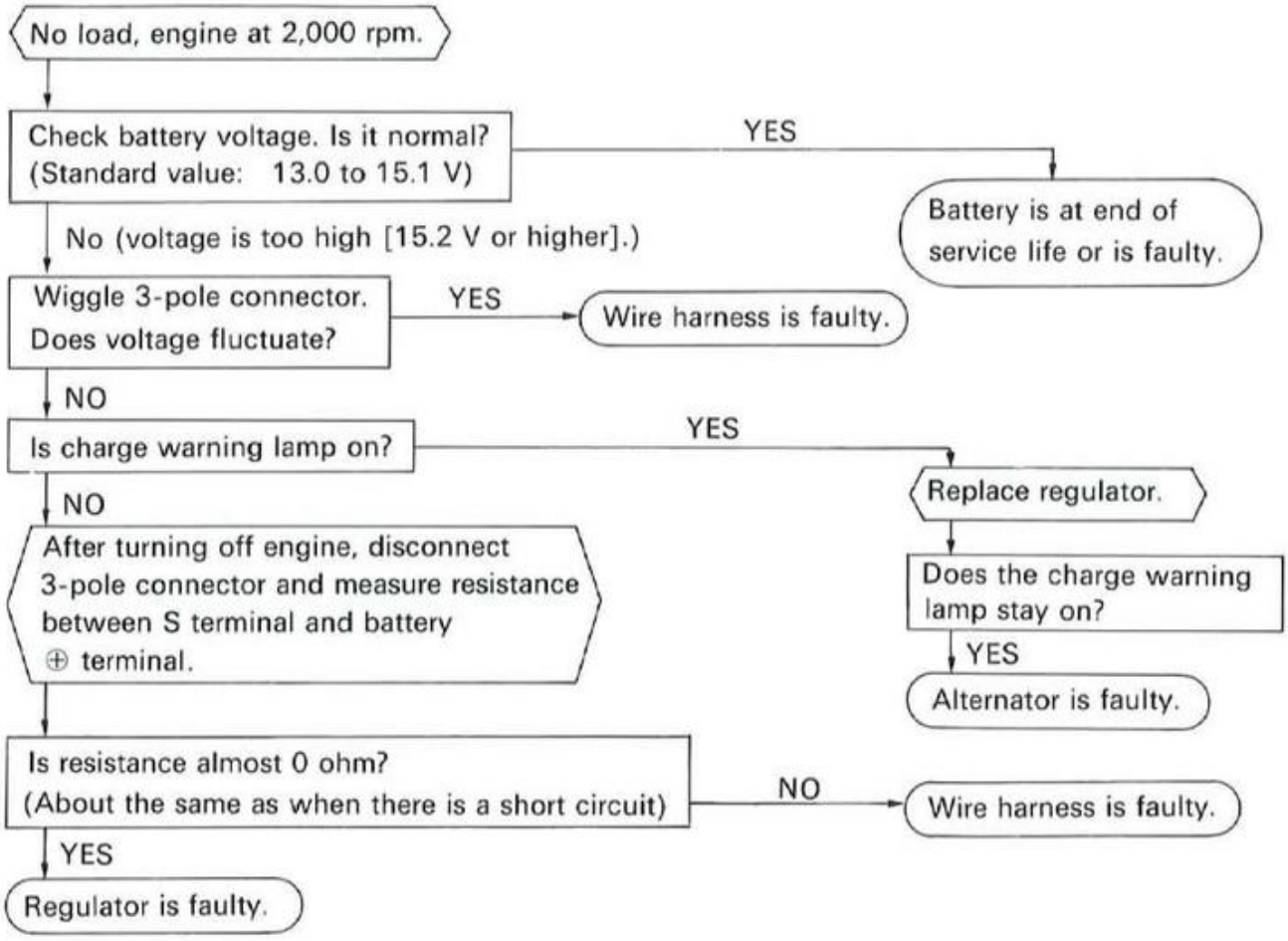
2. Charge warning lamp does not go out after engine is started.



* The voltage will fluctuate wildly, so this should be done in a short time (within 30 seconds). However, if it rises to 20 V or greater, stop the test immediately.


Voltage is normal.
Charge warning lamp lights faintly.
Turn IG switch on after turning engine off.
Does lamp glow brightly?
YES
NO
Disconnect 3-pole connector.
Is L terminal voltage 2 V or higher?
NO
Wire harness is faulty.
YES
Ground L terminal.
Does lamp glow brightly?
NO
Wire harness is faulty.
YES
Reconnect 3-pole connector.
With ignition switch off, start the engine and wiggle 3-pole connector.
Does lamp go off or blink?
YES
3-pole connector is faulty.
No (continues to glow dimly.)
(Repeat 2 – 3 times.)
Regulator is faulty.
Charge warning lamp glows brightly.
Disconnect 3-pole connector after turning engine off, then turn ignition switch to ON.
Does lamp glow brightly?
YES
Wire harness is faulty.
NO
Is 3-pole connector voltage normal?
S terminal: Battery voltage
IG terminal: Battery voltage
L terminal: 2 V or higher
YES
NO
Wire harness is faulty.
Reconnect 3-pole connector.
With ignition switch off, wiggle 3-pole connector, then start the engine.
Repeat 2 – 3 times.
Does the charge warning lamp go off?
No (lamp stays on.)
YES
Connector or wire harness is faulty.
Regulator is faulty.

3. Excessive consumption of battery electrolyte



ON-VEHICLE INSPECTION

OBJECTIVE : To learn the procedure for comprehensive on-vehicle inspection of the charging system.

PREPARATIONS :
- Repair Manual (for the model used in training)
- SST
  09081-00011 Alternator Checker
  09216-00020 Belt Tension Gauge (Recommended tool)
  09216-00030 Belt Tension Gauge Cable (Recommended tool)
  (or Nippondenso BTG-20 (95506-00020), Borroughs No. BT-33-73F)
- Engine Tachometer
- Circuit Tester (Volt- and Ohmmeter or Multi-meter)
- Ammeter (50 A)
- Battery Hydrometer

APPLICABLE MODEL : Y series engine (Aug., 1985)

PROCEDURE:

If the alternator is under charging or overcharging and it is thought that the charging system is faulty, the alternator or regulator should not be immediately removed from the vehicle.
First, an on-vehicle inspection should be performed to determine whether the cause is actually the alternator on the regulator or if there is another cause. Then the technician should proceed to inspection of individual components.

CHECK AND INSPECTION ITEMS

1 Check Battery Specific Gravity
2 Check Battery Terminals, Fusible Links and Fuses
3 Inspect Drive Belt
4 Visually check Alternator Wiring and Listen for Abnormal Noises
5 Inspect Charge Warning Light Circuit
6 Check Charging Circuit without Load
7 Check Charging Circuit with Load

NOTICES WHEN HANDLING THE CHARGING SYSTEM

1) Be careful of the polarity of the battery. Do not connect the battery with the poles reversed.

2) Since battery voltage is always applied to the B terminal of the alternator, the B terminal must never be grounded.

3) If the battery is charged rapidly using a quick charger, it could damage the diodes. Be sure to disconnect the battery cables when using a quick charger.

4) Be careful not to get water on the alternator or other electrical components when washing the vehicle.

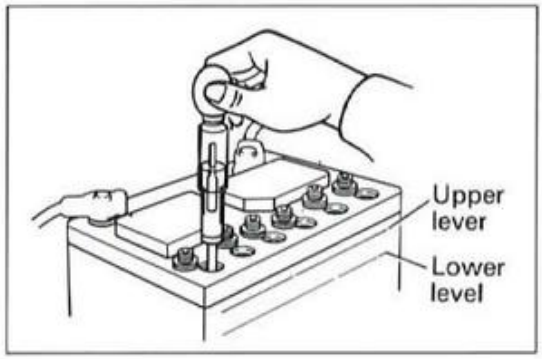
5) The engine should never be cranked with the B terminal of the alternator disconnected. This is because voltage regulation is not occurring at such a time, so the neutral terminal voltage (the voltage at the N terminal) could rise and burn out the relay coil. If the B terminal is disconnected, the wire connected to the F terminal (alternator connector) should always be disconnected too.

6) The alternator and regulator should be securely grounded. If they are not securely grounded, it could cause overcharging, flickering of the lights, oscillating of the ammeter needle, etc.

7) A condenser should never be connected to the F terminal to prevent noise, etc., as this could cause a deposit to build up on the regulator contact points.

8) The F terminal and IG terminal should not be connected in reverse for any reason. If they are connected in reverse, it could cause the wire harness to burn up.

9) Since the case of the IC regulator should have the electrical potential of ground, be sure to tighten the bolts to the alternator securely and make sure it is grounded.



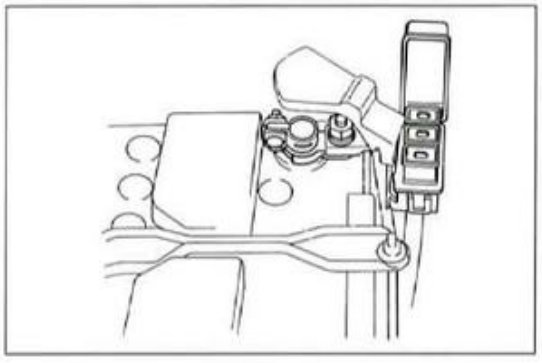
1. CHECK BATTERY SPECIFIC GRAVITY

(a) Check the specific gravity of each cell.

Standard specific gravity
When fully charged at 20°C (68°F): 1.25 – 1.27

(b) Check the amount of electrolyte in each cell.

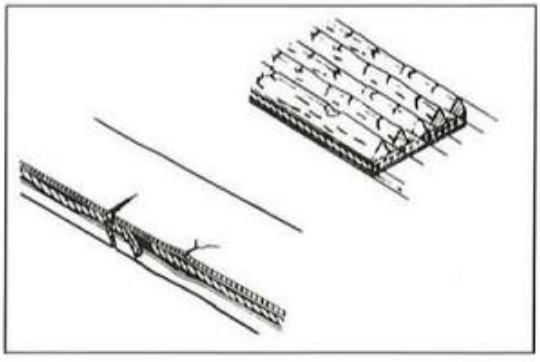
If insufficient, refill with distilled (or purified) water.



2. CHECK BATTERY TERMINALS, FUSIBLE LINKS AND FUSES

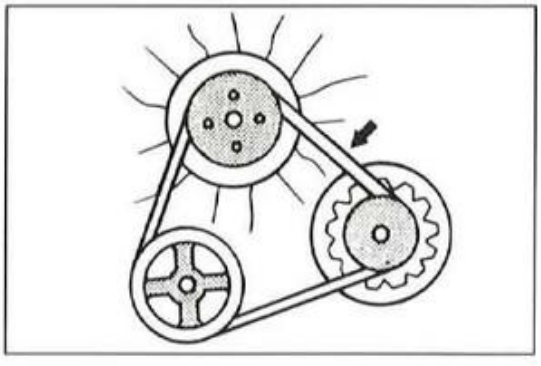
(a) Check that the battery terminals are not loose or corroded.

(b) Check the fusible links and fuses for continuity.



3. INSPECT DRIVE BELT

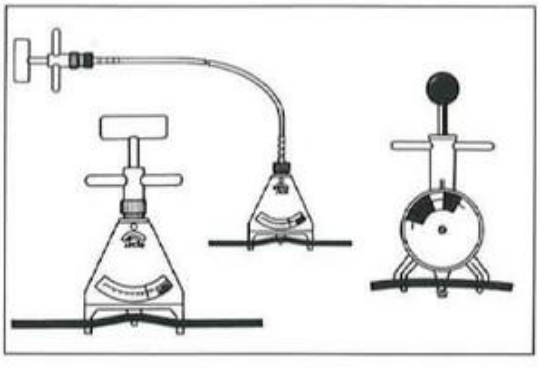
(a) Visually check the belt for separation of the adhesive rubber above and below the core, core separating from the belt side, severed core, separation of the ribs from the adhesive rubber, cracking or separation of the ribs, torn or worn ribs or cracks in the inner ridges of the ribs. If necessary, replace the drive belt.



(b) Check the drive belt deflection by pressing on the belt at the points indicated in the figure with 10 kg (22.0 lb) of pressure.

Drive belt deflection:
New belt 5 – 7 mm (0.20 – 0.28 in.)
Used belt 7 – 8 mm (0.28 – 0.31 in.)

If necessary, adjust the drive belt deflection



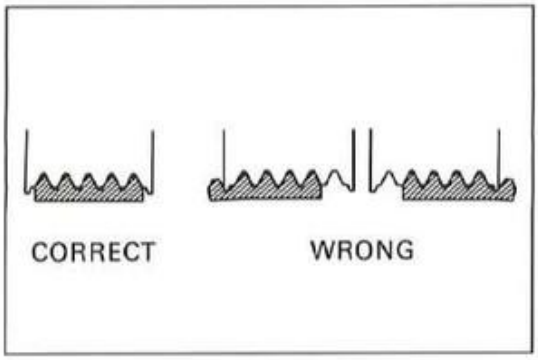
REFERENCE

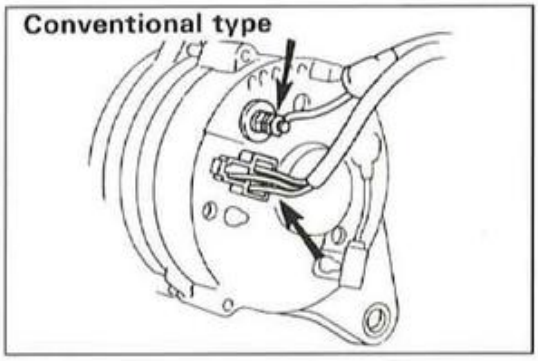
Using the SST, check the drive belt tension.

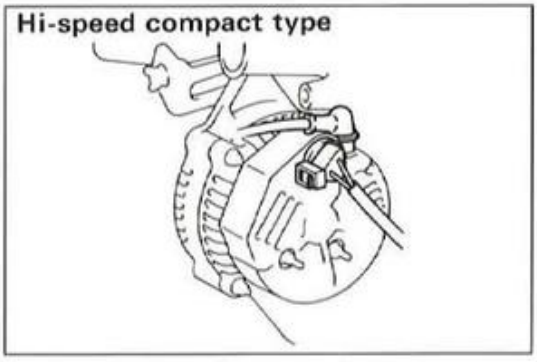
SST 09216-00020 and 09216-00030

Drive belt tension:
New belt 53 – 73 kg
Used belt 26 – 46 kg

If necessary, adjust the drive belt tension.







NOTE:

- "New belt" refers to a belt which has been used less than 5 minutes on a running engine.
- "Used belt" refers to a belt which has been used on a running engine for 5 minutes or more.
- After installing the drive belt, check to see that it fits properly in the ribbed grooves.
- Check with your hand to confirm that the belt has not slipped out of the grooves on the bottom of the crank pulley.
- After installing the belt, run the engine for approx. 5 minutes and recheck the deflection or tension.

4. VISUALLY CHECK ALTERNATOR WIRING AND LISTEN FOR ABNORMAL NOISES

(a) Check that the wiring is in good condition.

(b) Check that there are no abnormal noises from the alternator while the engine is running.

5. INSPECT CHARGE WARNING LAMP CIRCUIT

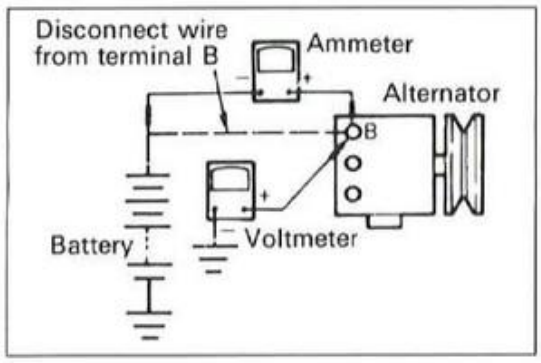
(a) Warm up the engine and then turn if off.

(b) Turn off all accessories.

(c) Turn the ignition switch to "ON". Check that the charge warning lamp is lit.

(d) Start the engine. Check that the light goes out.

If the light does not operate as specified, troubleshoot the charge warning lamp circuit.

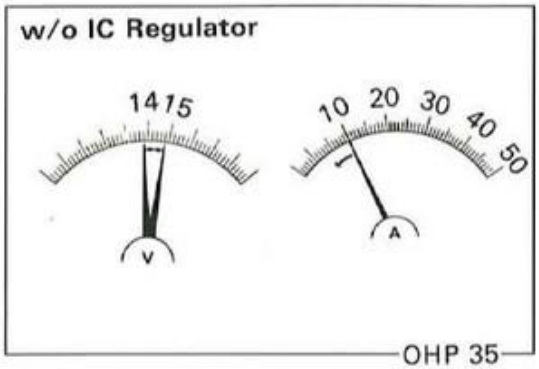


6. CHECK CHARGING CIRCUIT WITHOUT LOAD

NOTE: If a battery/alternator tester is available, connect the tester to the charging circuit as per manufacturer's instructions.

(a) If such a tester is not available, connect a voltmeter and ammeter to the charging circuit as follows:

- Disconnect the wire from terminal B of the alternator and connect it to the negative probe of the ammeter.
- Connect the test probe from the positive terminal of the ammeter to terminal B of the alternator.
- Connect the positive probe of the voltmeter to terminal B of the alternator.
- Connect the negative probe of the voltmeter to ground.

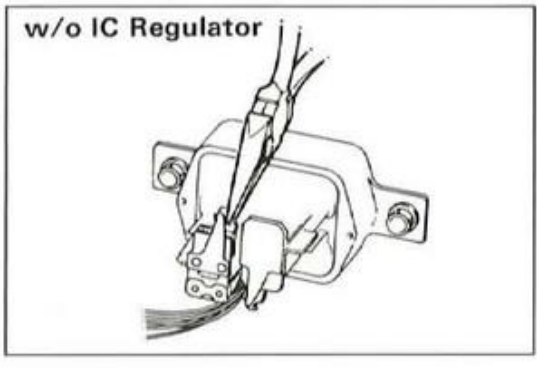


(b) Check the charging circuit as follows:

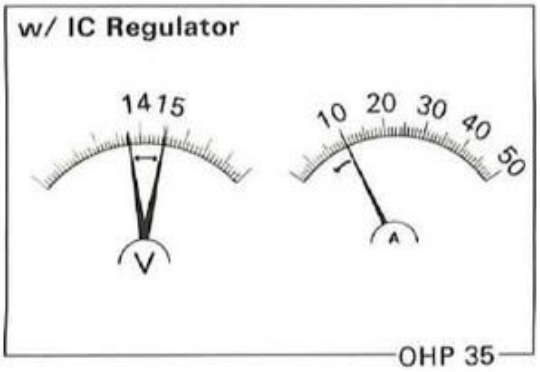
With the engine running from idle to 2,000 rpm, check the reading on the ammeter and voltmeter.

Without IC Regulator

Standard amperage: Less than 10 A
Standard voltage: 13.8 – 14.8 V at 25°C (77°F)



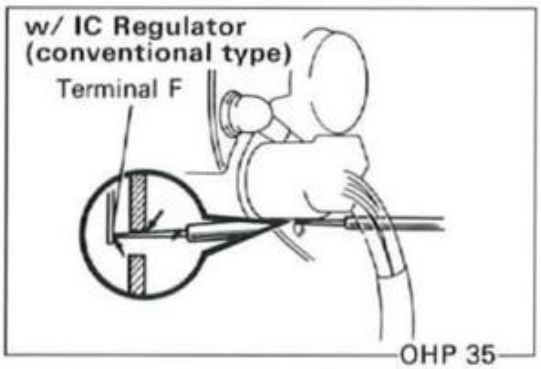
If the voltage reading is not within standard, adjust the regulator or replace it.

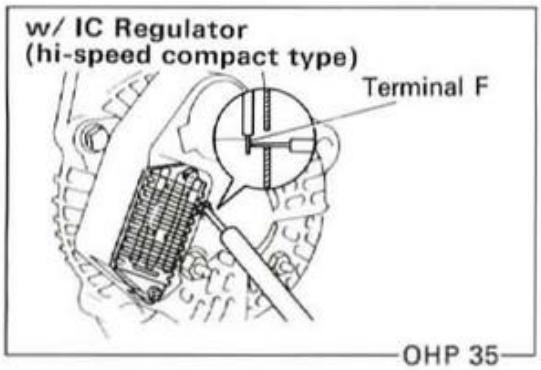


With IC Regulator

Standard amperage: Less than 10 A
Standard voltage:
Hi-speed compact type
13.5 – 15.1 V at 25°C (77°F)

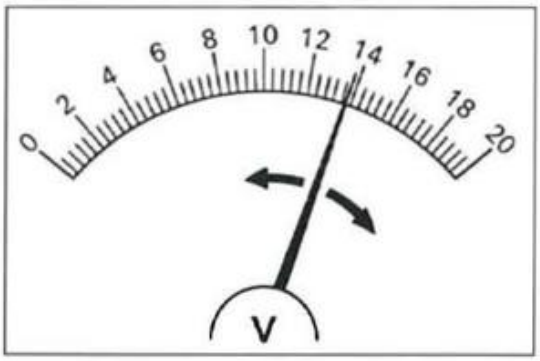
If the voltage reading is greater than standard replace the IC regulator.



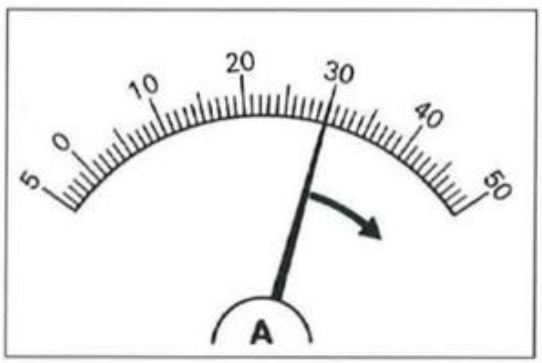


If the voltage reading is less than standard, check the IC regulator and alternator as follows:

- With terminal F grounded, start the engine and check the voltage reading of terminal B.



- If the voltage reading is greater than standard voltage, replace the IC regulator.
- If the voltage reading is less than standard, check the alternator.

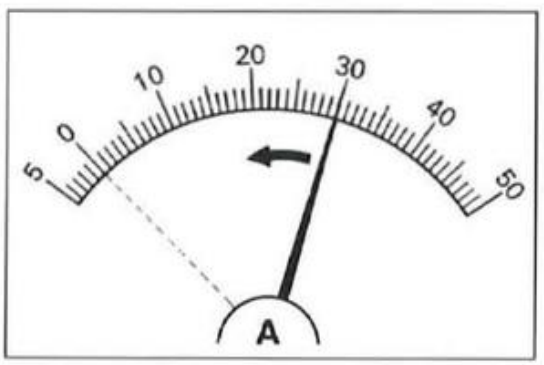


7. CHECK CHARGING CIRCUIT WITH LOAD

(a) With the engine running at 2,000 rpm, turn on the high-beam headlights and place the heater fan control switch to "HI".

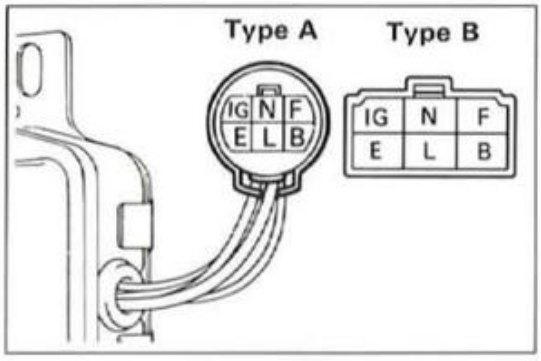
(b) Check the reading on the ammeter.

Standard amperage: More than 30 A



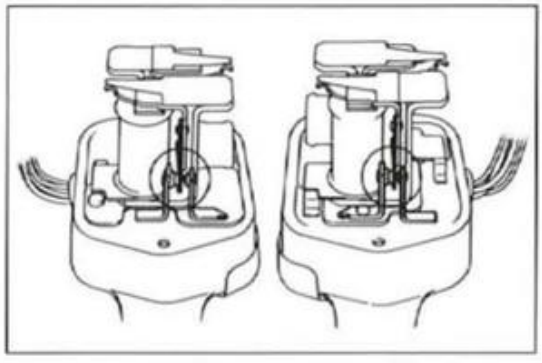
If the ammeter reading is less than 30 A, repair the alternator.

NOTE: With the battery fully charged, the indication will sometimes be less than 30 A.



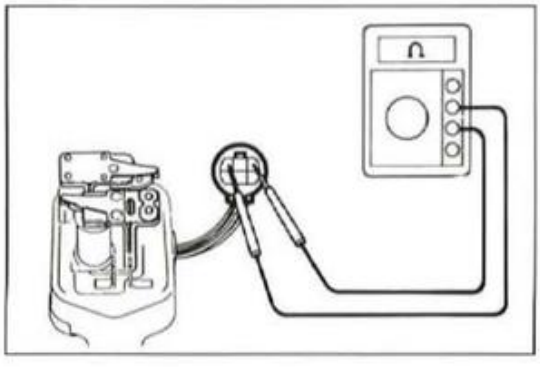
INSPECTION OF ALTERNATOR REGULATOR

1. REMOVE ALTERNATOR REGULATOR COVER



2. INSPECT POINT SURFACES FOR BURNING OR DAMAGE

If defective, replace the regulator.

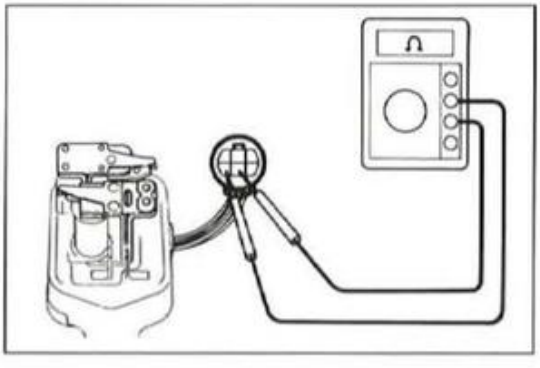


3. INSPECT RESISTANCE BETWEEN TERMINALS

(a) Using an ohmmeter, measure the resistance between terminals IG and F.

Resistance (voltage regulator):

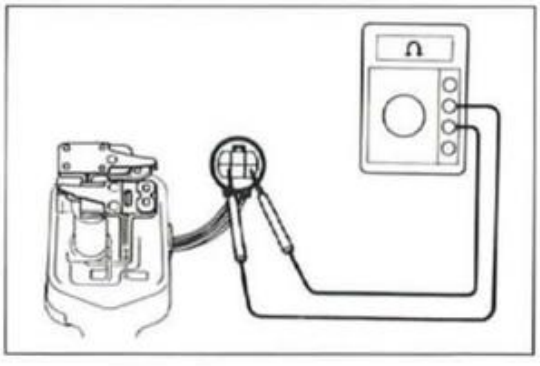
At rest	**O Ω**
Pulled in	**Approx. 11 Ω**



(b) Using an ohmmeter, measure the resistance between terminals L and E.

Resistance (voltage regulator):

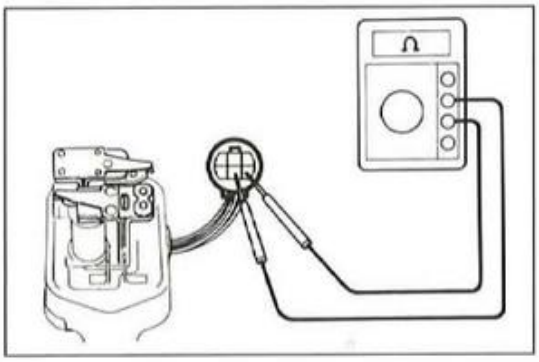
At rest	**O Ω**
Pulled in	**Approx. 100 Ω**



(c) Using an ohmmeter, measure the resistance between terminals B and E.

Resistance (voltage relay):

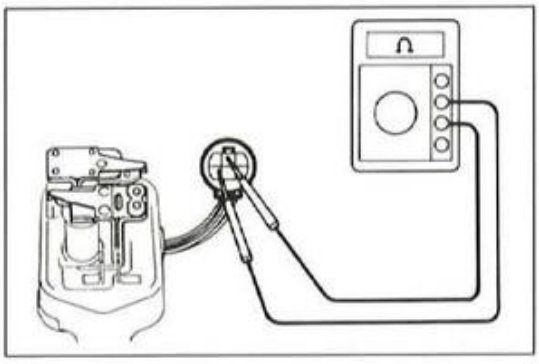
At rest	**Infinity**
Pulled in	**Approx. 100 Ω**



(d) Using an ohmmeter, measure the resistance between terminals B and L.

Resistance (voltage relay):

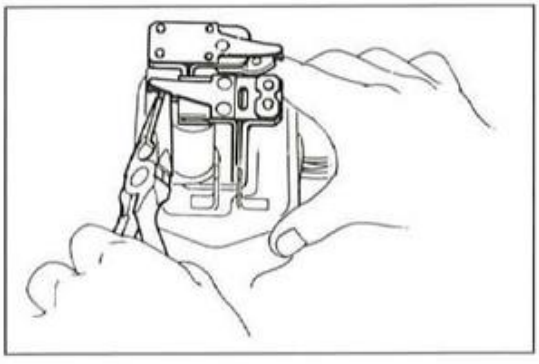
At rest	**Infinity**
Pulled in	**Approx. 0 Ω**



(e) Using an ohmmeter, measure the resistance between terminals N and E.

Resistance: Approx. 24 Ω

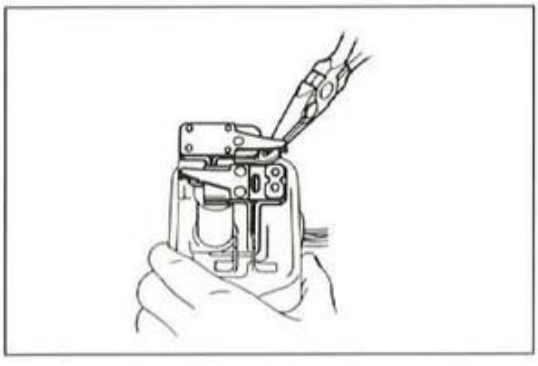
If any of the above checks are not positive, replace the alternator regulator.



4. ADJUST VOLTAGE REGULATOR

(a) Adjust the voltage regulator by bending the regulator adjusting arm.

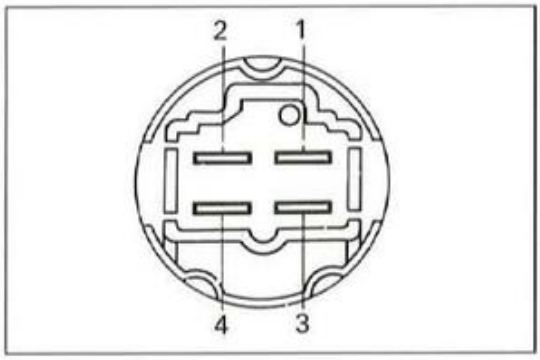
Standard voltage: 13.8 – 14.8 V



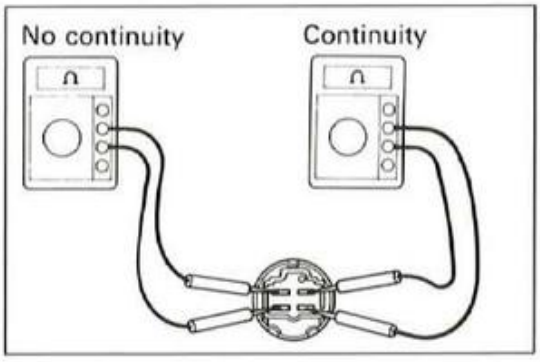
(b) Adjust the voltage relay by bending the relay adjusting arm.

Relay actuating voltage: 4.0 – 5.8 V

5. INSTALL ALTERNATOR REGULATOR COVER



INSPECTION OF IGNITION MAIN RELAY

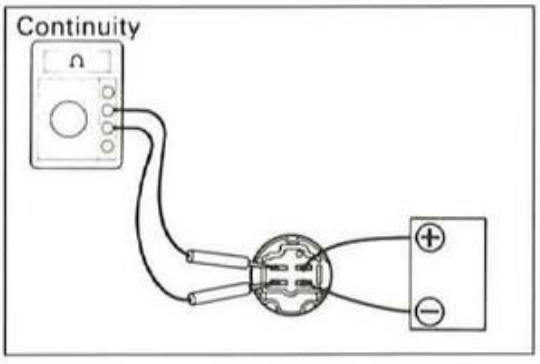


1. INSPECT RELAY CONTINUITY

(a) Check that there is continuity between terminals 1 and 3.

(b) Check that there is no continuity between terminals 2 and 4.

If continuity is not as specified, replace the relay.



2. INSPECT RELAY OPERATION

(a) Apply battery voltage across terminals 1 and 3.

(b) Check that there is continuity between terminals 2 and 4.

If continuity is not as specified, replace the relay.

OVERHAUL

OBJECTIVE : To learn how to overhaul the alternator and regulator

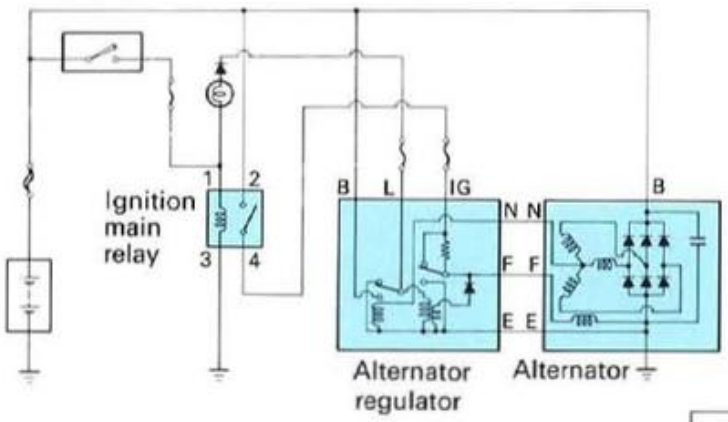
PREPARATIONS :

- Repair Manual (for the model used in training)
- SST

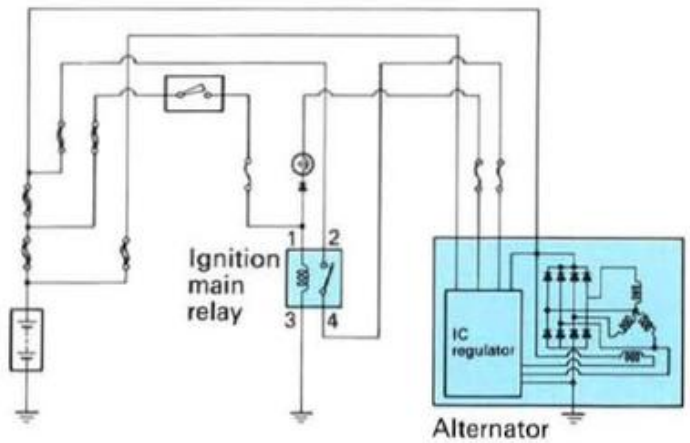
09285-76010	Injection Pump Camshaft Bearing Cone (for rotor rear bearing replacement)
09286-46011	Injection Pump Spline Shaft Puller (for rear bearing removal)
09608-20012	Front Hub & Drive Pinion Bearing Tool Set (for alternator rear bearing removal)
09820-63010	Alternator Pulley Set Nut Wrench Set (for compact alternator only)
09820-00021	Alternator Rear Bearing Puller (for compact alternator only)

- Electrical Solder
- Circuit Tester (Volt-and Ohmmeter, Multi-meter)
- Vernier Calipers 32.5 mm (1.280 in)
- Torque Wrench 1,125 kg-cm (29 ft-lb, 110 N·m)
- High-temperature Grease

Conventional type



Hi-speed compact type

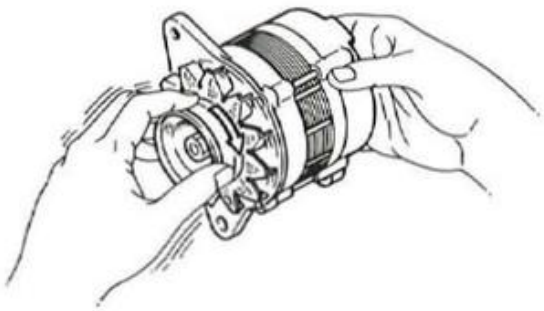


PRE-INSPECTION

Before disassembling the alternator, perform the following pre-checks. The results of these pre-checks will prove helpful when inspecting each individual component later on.

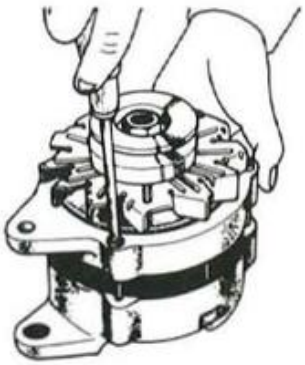
1. ABNORMAL NOISE TEST

Turn the alternator by hand. Check for smooth rotation and listen for any abnormal noise.



The alternator has bearings inside. If these bearings are damaged in some way, the alternator will not turn smoothly and you will hear a noise. Also, you can tell to some extent if the brushes or slip rings are damaged by turning the alternator.

This same test should also be done after reassembling the alternator to check that it has been reassembled properly.



2. CONTINUITY TEST

The circuit tester utilizes dry cell batteries. A very small amount of current will flow when the tester probes make contact with the circuit to be tested, and the resistance value of the circuit can be measured by the extent of this current.

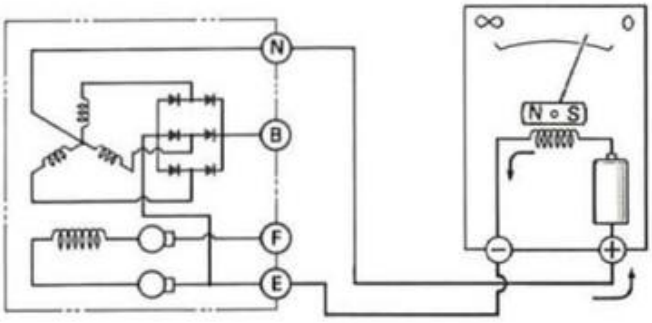
NEGATIVE SIDE RECTIFIER SHORT TEST

By checking the continuity between terminals N and E of the alternator, it is possible to find out if the positive side diodes are short-circuited or not.

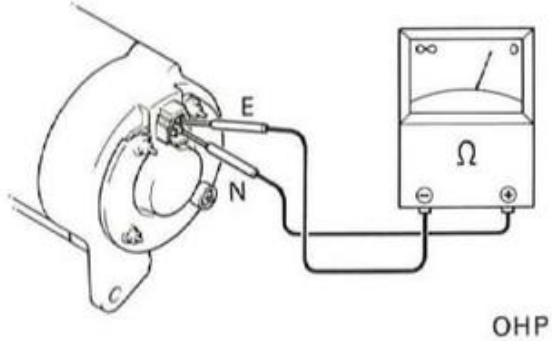
The circuit tester utilizes dry cell batteries. A very small amount of current will flow when the tester probes make contact with the circuit to be tested, and the resistance value of the circuit can be measured by measuring the amount of this current.

When the two tester probes make contact with terminals N and E of the alternator, the indicator needle of the tester may or may not fluctuate, depending on whether or not there is battery current flowing.

When the positive prove is touched to terminal N and the negative probe to terminal E, there will be a flow of battery current and the tester needle will swing towards zero if there is continuity between all diodes on the negative side.



OHP 36

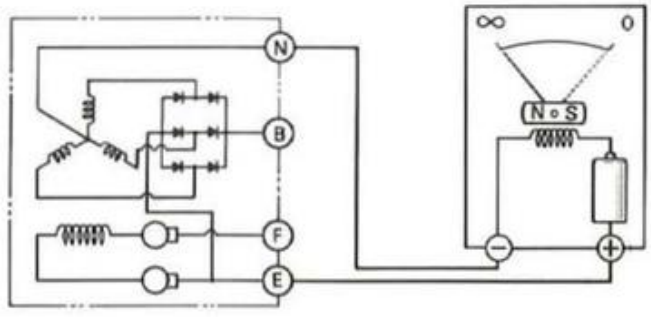


OHP 36

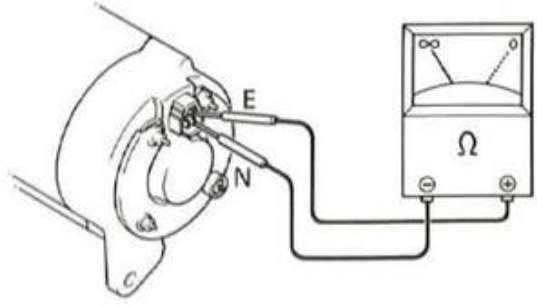
NOTE: The amount of current, that is the resistance of the diodes, will change, depending on the selected range of the circuit tester. Therefore, it is difficult to tell if a semiconductor, such as a diode, is bad or not by the resistance value alone.

Conversely, if there is no continuity between the negative side diodes, no battery current will flow when the negative probe is touched to terminal N and the positive probe is touched to terminal E. If the tester needle does move, it means that there is current flowing and there are one or more short-circuited diodes on the negative side.

If the diodes are normal, current will flow in one direction only. If current flows in both directions, the diodes are defective and this is called a short-circuit. On the other hand, if current does not flow in either direction, it is called an open circuit.



OHP 36

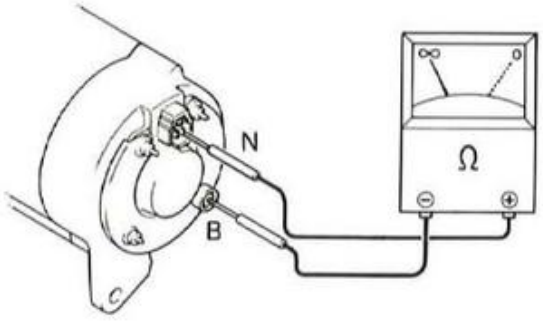


REFERENCE

When measuring resistance with a circuit tester, the current is output through the negative terminal if an analog tester is used. On some digital testers, the current is output through the positive terminal.
With most digital testers, the range for diodes must be selected before a diode can be tested.

POSITIVE SIDE RECTIFIER SHORT CIRCUIT TEST

You can find out of if there is a short circuit in the positive side diodes by checking the continuity between terminals N and B of the alternator.
If all the diodes on the positive side are normal, the tester needle will not move when the negative tester probe is touched to terminal B and the positive probe to terminal N. If the needle does move, that is, if there is continuity, a short circuit is indicated in the positive side diodes.

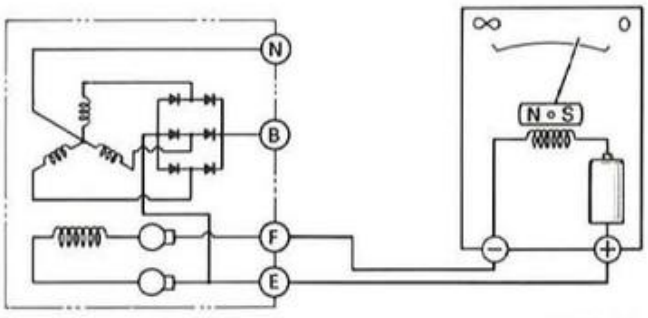


If the positive tester probe is touched to terminal B and the negative probe to terminal N, battery current will flow and the tester needle will swing to zero under normal conditions. In other words, there will be continuity between terminals B and N.

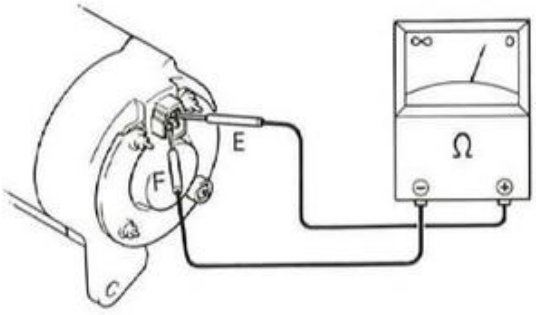
However, if there is an open circuit between all the positive side diodes (though this rarely happens), the tester needle will not move when the probes are touched to the terminals. In this case, the charge warning lamp will go out just as when the engine is started, but the battery will not be recharged because there is no output current from terminal B of the alternator.

ROTOR COIL RESISTANCE TEST

By checking for continuity between terminals F and E of the alternator, you can find out whether or not there is an open in the rotor coil or if there is bad contact between the brushes and slip rings.



OHP 36



As field current for the rotor coil is flowing in the circuit between terminals F and E, there should be continuity between these two terminals, and the resistance value should be around 4 ohms.

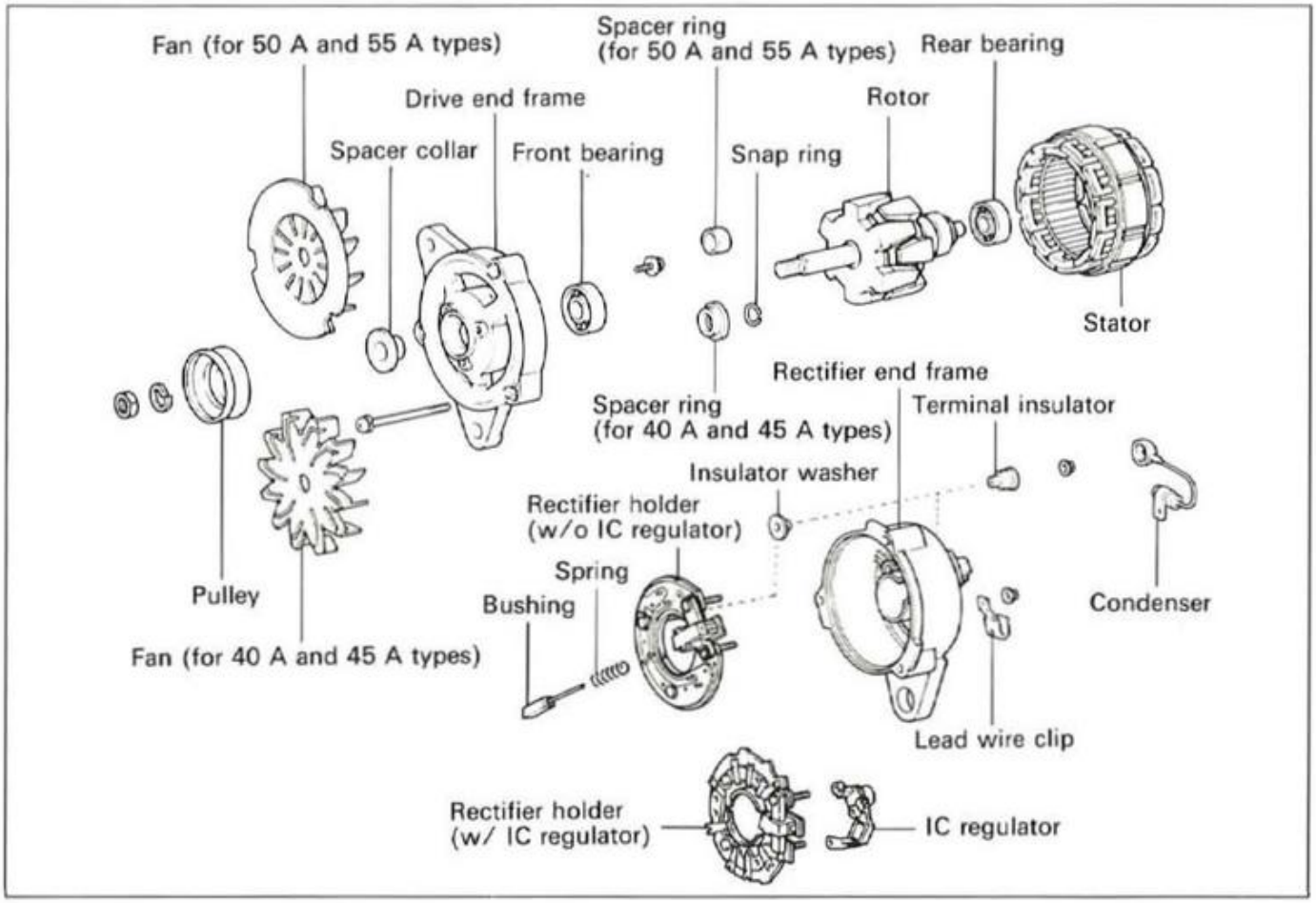
If there is no continuity, there is either an open in the rotor coil or poor contact between the brushes and slip rings.

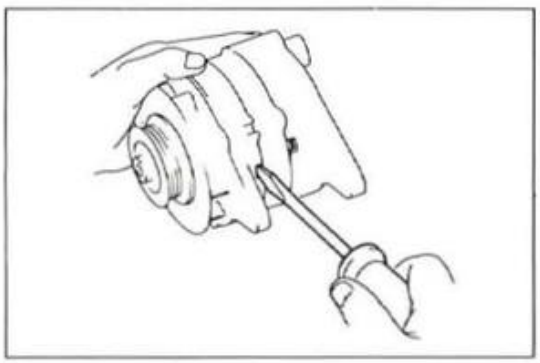
With this test, the positive and negative probes may touch either terminal E or F. In other words, because the rotor coil is not a semiconductor, tester battery current can flow in either direction.

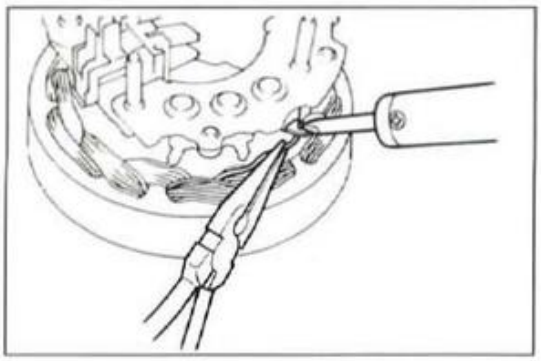
ALTERNATOR (Conventional Type)

• Y series engine (Aug., 1985)

COMPONENTS







MAIN POINT IN ALTERNATOR OVERHAUL

DISASSEMBLY OF ALTERNATOR

1. REMOVE DRIVE END FRAME AND ROTOR ASSEMBLY FROM STATOR

(a) Remove the three through screws.

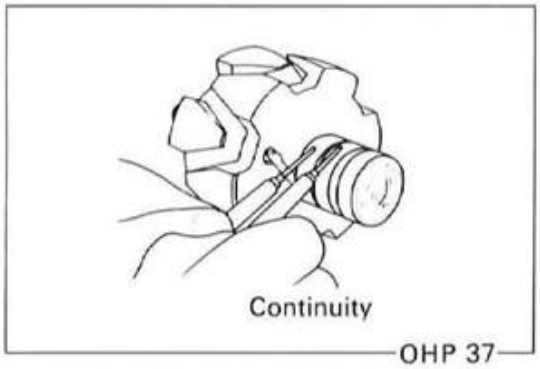
(b) Using a screwdriver, pry the end frame and remove it together with the rotor.

NOTICE: Do not pry on the coil wires.

2. REMOVE RECTIFIER HOLDER

Hold the rectifier terminal with needle-nose pliers and unsolder the leads.

NOTICE: Protect the rectifier from heat.
As the rectifier is very sensitive to heat, always use needle-nose pliers to protect it when soldering as shown to the left. Also, carry out the soldering as quickly as possible to prevent the rectifier from overheating.



INSPECTION OF ALTERNATOR

Rotor

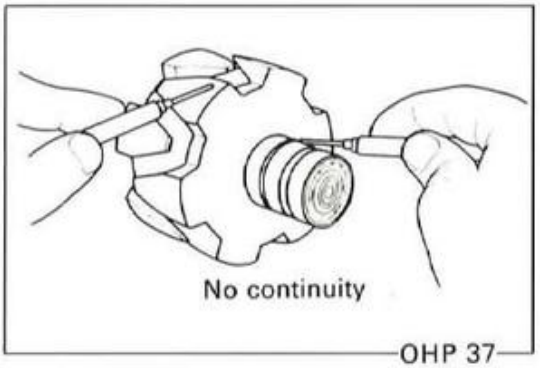
1. INSPECT ROTOR FOR OPEN CIRCUIT

Using an ohmmeter, check that there is continuity between the slip rings.

Standard resistance (cold):

w/o IC Regulator	**3.9 – 4.1 Ω**
w/ IC Regulator	**2.8 – 3.0 Ω**

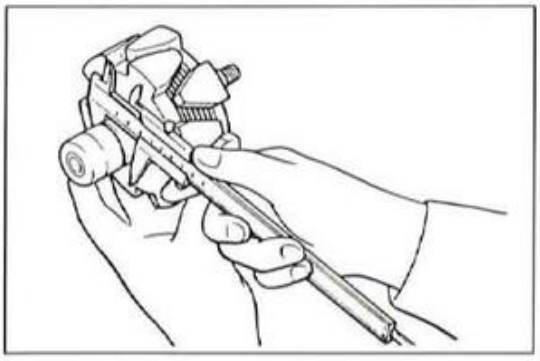
If there is no continuity, replace the rotor.



2. INSPECT THAT ROTOR IS GROUNDED

Using an ohmmeter, check that there is no continuity between the slip ring and the rotor.

If there is continuity, replace the rotor.



3. INSPECT SLIP RINGS

(a) Check that the slip rings are not rough or scored.

If rough or scored, replace the rotor.

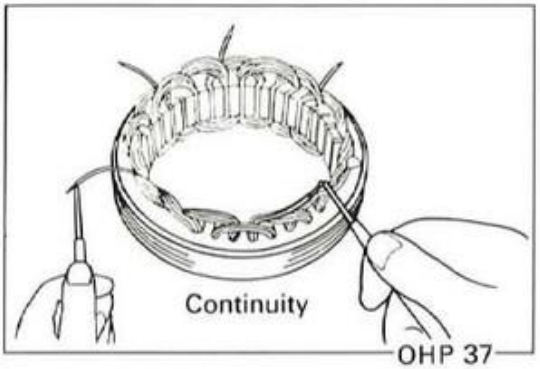
(b) Using calipers, measure the slip ring diameter.

Standard diameter: 32.3 – 32.5 mm (1.272 – 1.280 in.)

Minimum diameter: 32.1 mm (1.264 in.)

If the diameter is less than minimum, replace the rotor.

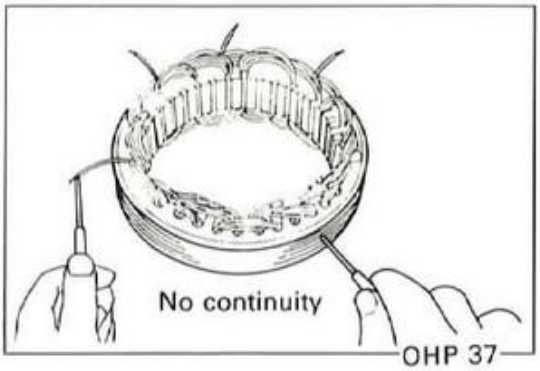
Stator



1. INSPECT STATOR FOR OPEN CIRCUIT

Using an ohmmeter, check that there is continuity between the coil leads.

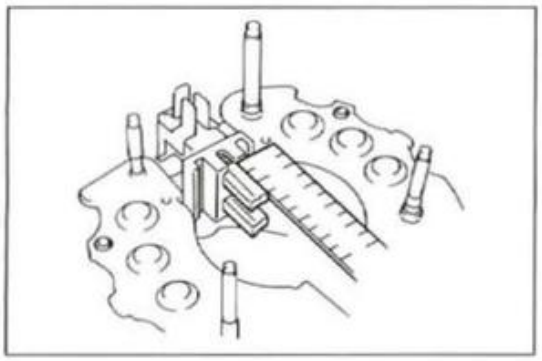
If there is no continuity, replace the stator.



2. INSPECT THAT STATOR IS GROUNDED

Using an ohmmeter, check that there is no continuity between the coil leads and stator core.

If there is continuity, replace the stator.



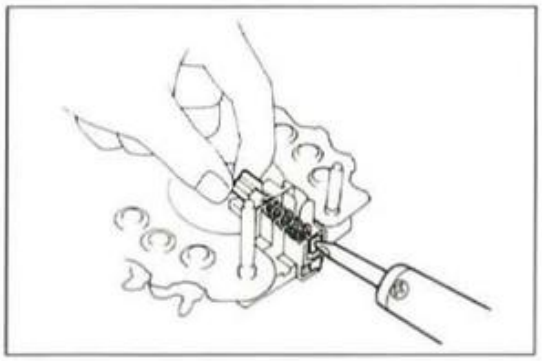
Brushes

1. MEASURE EXPOSED BRUSH LENGTH

Using a scale, measure the length of the exposed brush.

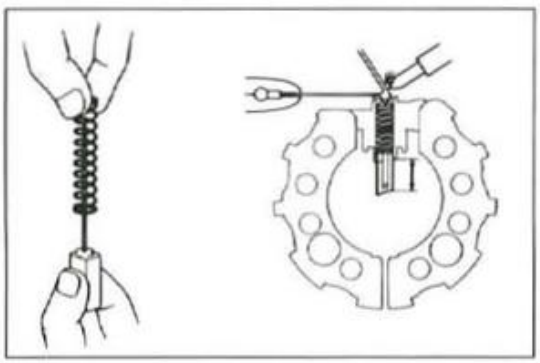
Standard exposed length:
w/o IC Regulator 12.5 mm (0.492 in.)
w/ IC Regulator 16.5 mm (0.650 in.)
Minimum exposed length: 5.5 mm (0.217 in.)

If the length is less than minimum, replace the brushes.



2. IF NECESSARY, REPLACE BRUSHES

(a) Unsolder and remove the brush and spring.



(b) Insert the brush wire through the spring.

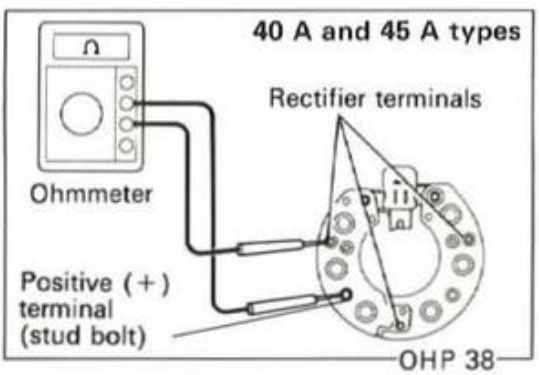
(c) Install the brush in the brush holder.

(d) Solder the wire to the brush holder at specifield exposed length.

Exposed length:
w/o IC Regulator 12.5 mm (0.492 in.)
w/ IC Regulator 16.5 mm (0.650 in.)

(e) Check that the brush moves smoothly in the brush holder.

(f) Cut off any excess wire.



Rectifiers (Rectifier Holder)

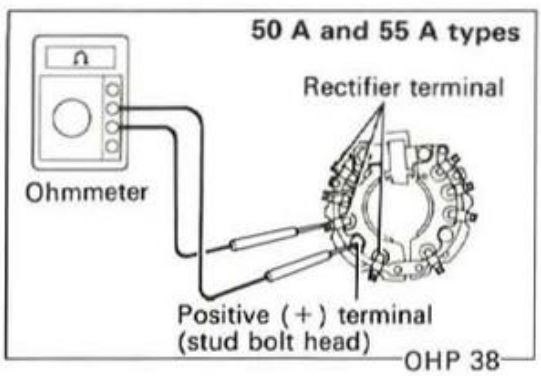
1. INSPECT POSITIVE RECTIFIER

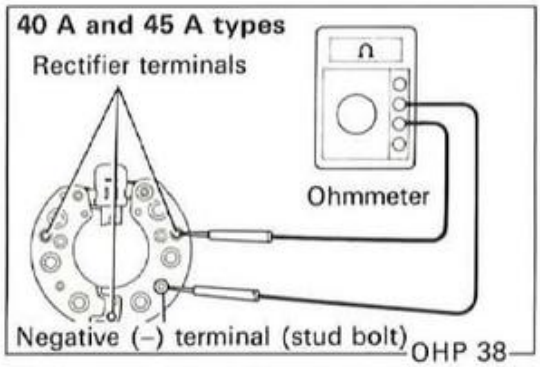
(a) Using an ohmmeter, connect the one test probe to each rectifier terminal and the other to positive terminal.

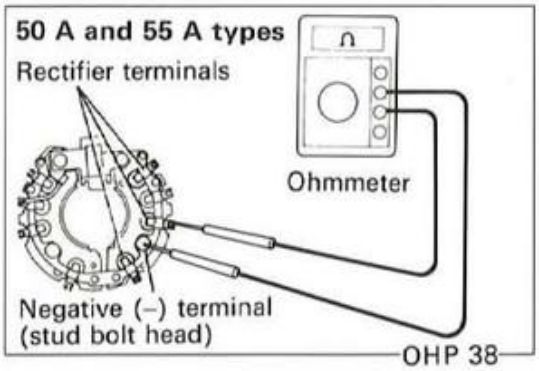
(b) Reverse the polarity of the probes, and repeat step (a).

(c) Check that one shows continuity and the other shows no continuity.

If continuity is not as specified, replace the rectifier holder.







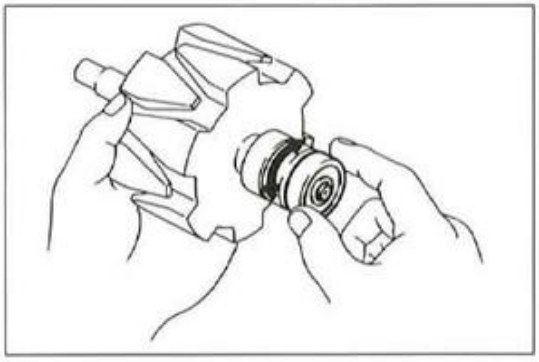
2. INSPECT NEGATIVE RECTIFIER

(a) Using an ohmmeter, connect the one test probe to each rectifier terminal and the other to the negative terminal.

(b) Reverse the polarity of the test probes, and repeat step (a).

(c) Check that one shows continuity and the other shows no continuity.

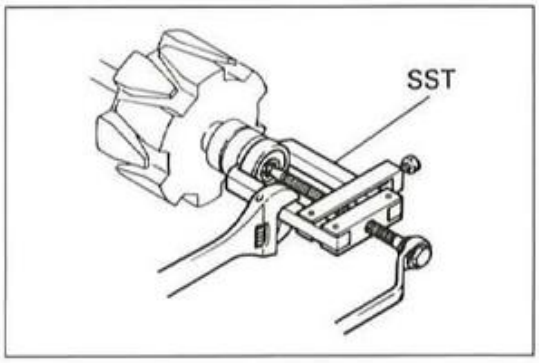
If continuity is not as specified, replace the rectifier holder.



Bearings

1. INSPECT REAR BEARING

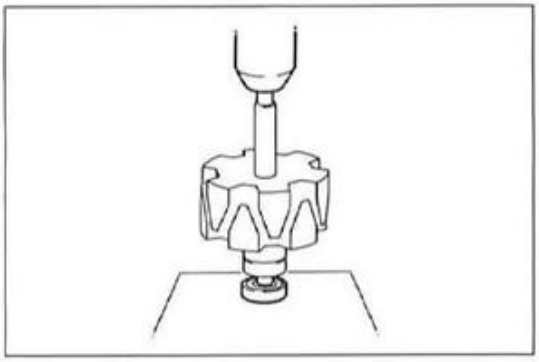
Check that the bearing is not rough or worn.



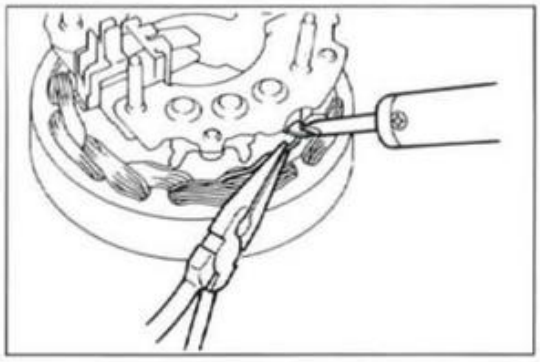
2. IF NECESSARY, REPLACE REAR BEARING

(a) Using the SST, remove the bearing.

SST 09286-46011



(b) Using a press, press in a new bearing.

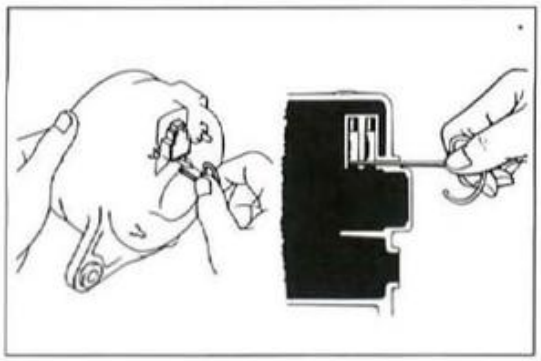


ASSEMBLY OF ALTERNATOR

1. INSTALL RECTIFIER HOLDER TO STATOR

Hold the rectifier terminal with needle-nose pliers while soldering the leads.

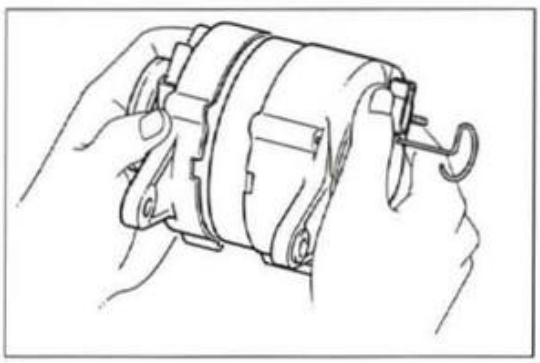
NOTICE: Protect the rectifier from heat.



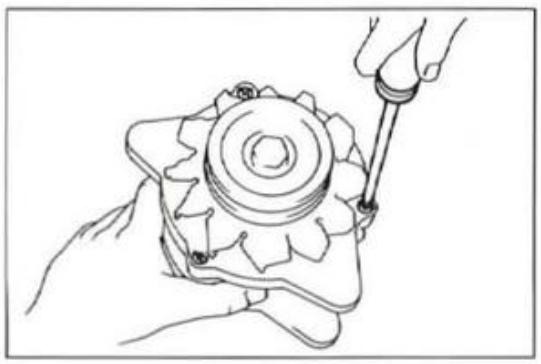
2. ASSEMBLE DRIVE END FRAME AND RECTIFIER END FRAME

(a) Bend the rectifier lead wires back to clear the rotor.

(b) Using a curved tool, push the brushes in as far as they will go and hold them in place by inserting a stiff wire through the access hole in the rectifier end frame.

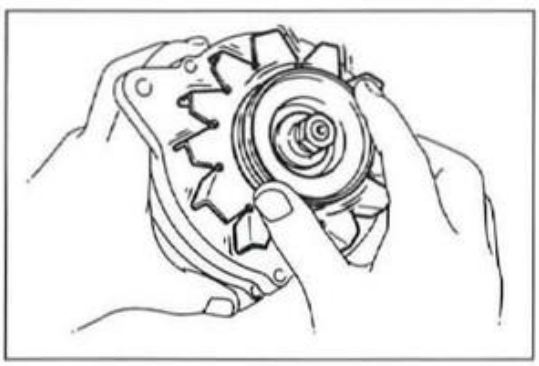


(c) Assemble the drive end frame and the rectifier end frame by inserting the rear bearing on the rotor shaft into the rectifier end frame.



(d) Install the three through screws.

(e) Remove the stiff wire from the access hole.



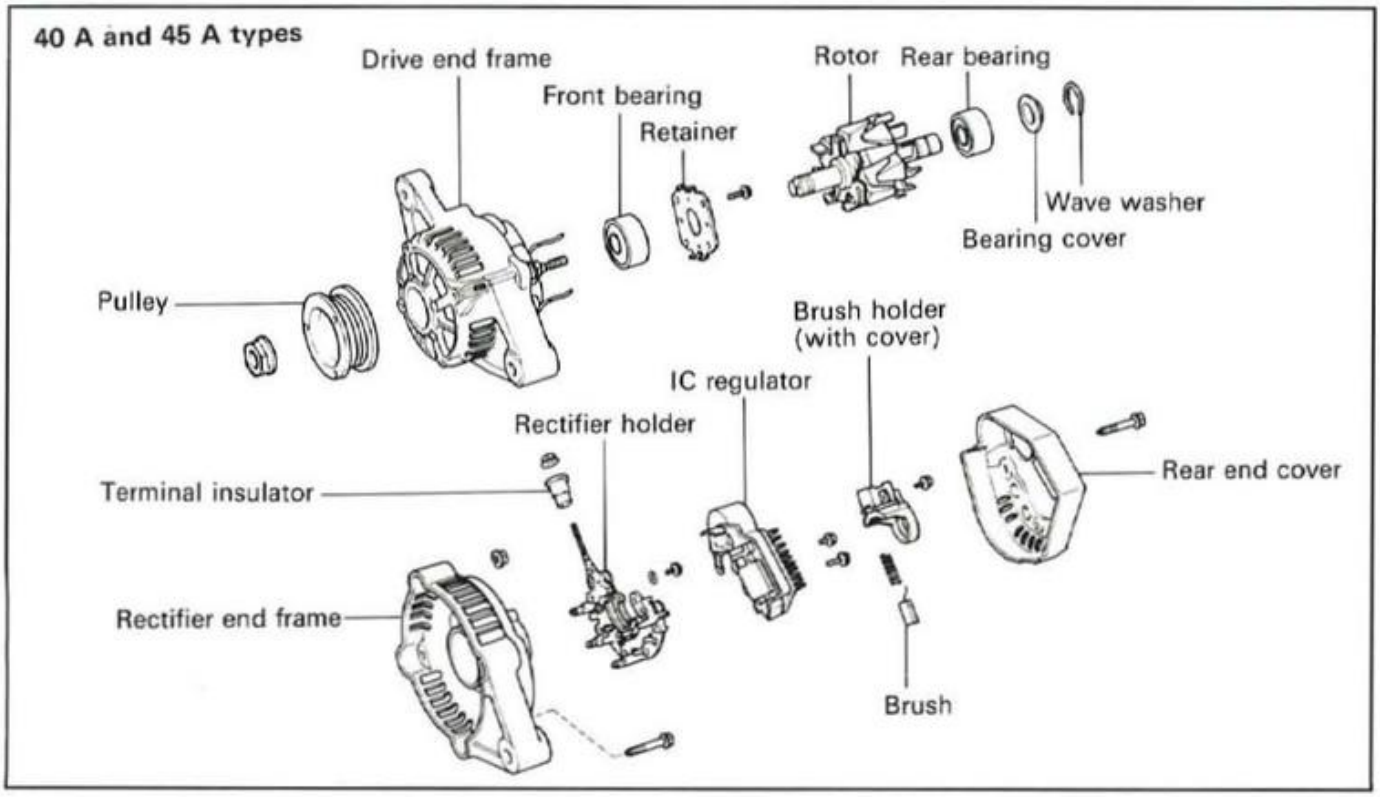
(f) Check that the rotor rotates smoothly.

(g) Seal the access hole.

ALTERNATOR (Hi-speed Compact Type)

• Y series engine (Aug., 1985)

COMPONENTS



Here we will discuss only those parts of the procedure that differ from that for the conventional type alternator.

DISASSEMBLY OF ALTERNATOR

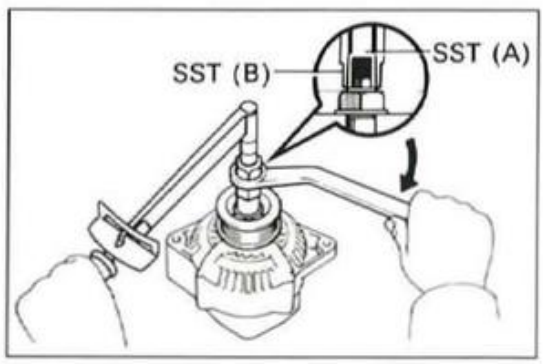
REMOVE PULLEY

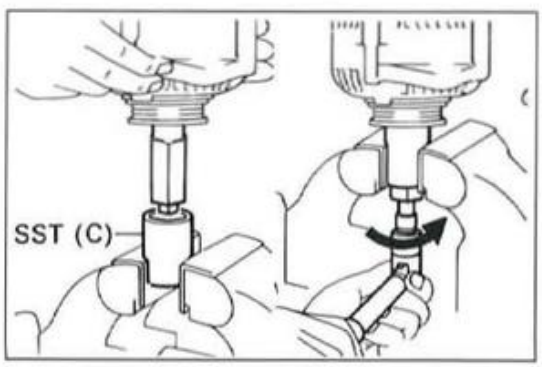
(a) Hold SST (A) with a torque wrench, and tighten SST (B) clockwise to the specified torque.

SST 09820-63010

Torque: 400 kg-cm (29 ft-lb, 39 N·m)

(b) Check that SST (A) is secured to the rotor shaft.





(c) As shown in the figure, mount SST (C) in a vise, and install the alternator to SST (C).

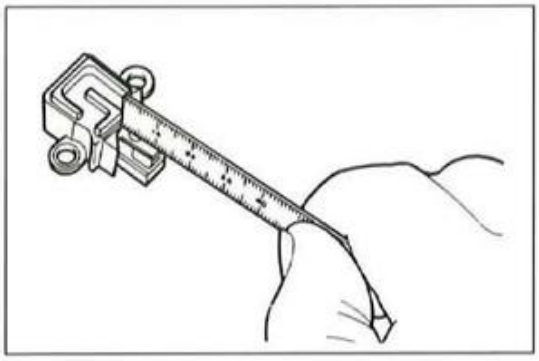
(d) To loosen the pulley nut turn SST (A) in the direction shown in the figure.

NOTICE: To prevent damage to the rotor shaft, do not loosen the pulley nut more that one-half of a turn.

(e) Remove the alternator from SST (C).

(f) Turn SST (B) and remove SSTs (A) and (B).

(g) Remove the pulley nut and pulley.



INSPECTION AND REPAIR OF ALTERNATOR

Rotor, stator, & Rectifier

Inspection of the rotor, stator, and rectifier is the same as for the alternator without IC regulator.

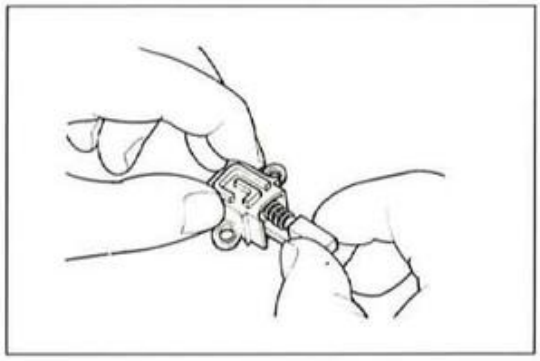
Brushes

1. MEASURE EXPOSED BRUSH LENGTH

Using a scale, measure the length of the exposed brush.

Standard exposed length: 10.5 mm (0.413 in.)
Minimum exposed length: 4.5 mm (0.177 in.)

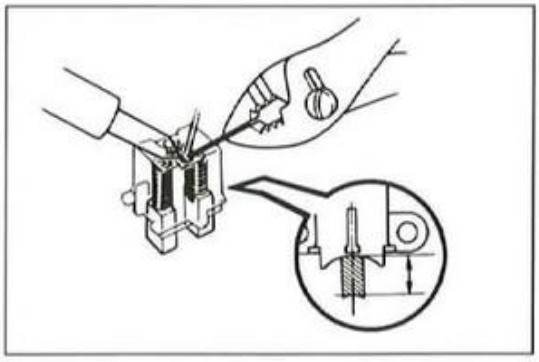
If the exposed length is less than minimum, replace the brushes.



2. IF NECESSARY, REPLACE BRUSHES

(a) Unsolder and remove the brush and spring.

(b) Run the wire of the brush through the hole in the brush holder, and insert the spring and brush into the brush holder.



(c) Solder the brush wire to the brush holder at the exposed length.

Exposed length: 10.5 mm (0.413 in.)

(d) Check that the brush moves smoothly in the brush holder.

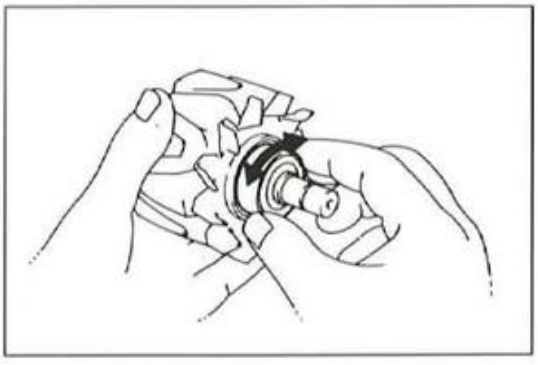
(e) Cut off the excess wire.

(f) Apply insulation paint to the soldered point.

Bearings

1. INSPECT REAR BEARING

Check that the bearing is not rough or worn.



2. IF NECESSARY, REPLACE BEARING

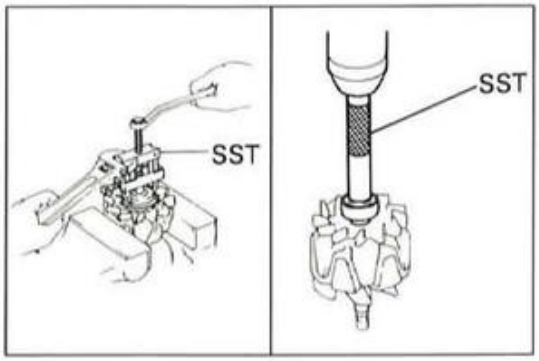
(a) Using the SST, remove the bearing cover and cover.

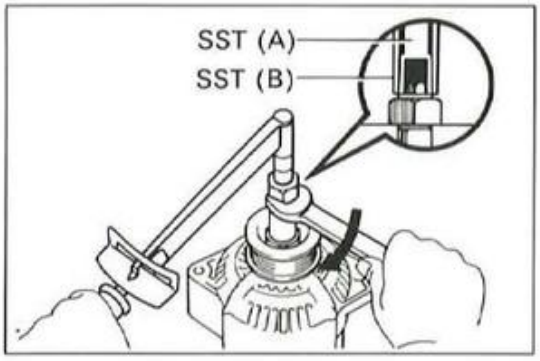
SST 09820-00021

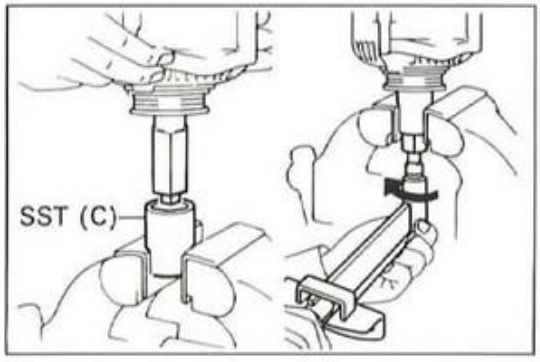
NOTICE: Be careful not to damage the fan.

(b) Using the SST and a press, press in the bearing and bearing cover.

SST 09285-76010







ASSEMBLY OF ALTERNATOR

1. INSTALL PULLEY

(a) Install the pulley to the rotor shaft by tightening the pulley nut by hand.

(b) Hold SST (A) with a torque wrench, and tighten SST (B) clockwise to the specified torque.

SST 09820-63010

Torque: 400 kg-cm (29 ft-lb, 39 N·m)

(c) Check that SST (A) is secured to the pulley shaft.

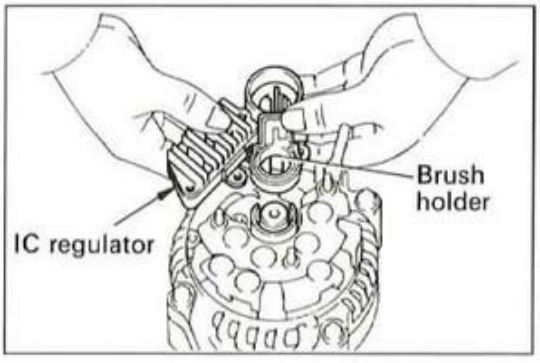
(d) As shown in the figure, mount SST (C) in a vise, and install the alternator to SST (C).

(e) To tighten the pulley nut, turn SST (A) in the direction shown in the figure.

Torque: 1,125 kg-cm (81 ft-lb, 110 N·m)

(f) Remove the alternator from SST (C).

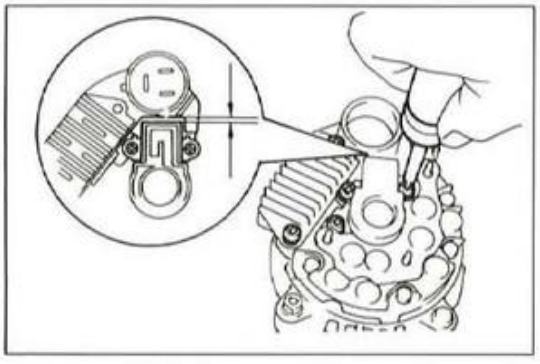
(g) Turn SST (B) and remove SSTs (A and B).



2. INSTALL BRUSH HOLDER AND IC REGULATOR

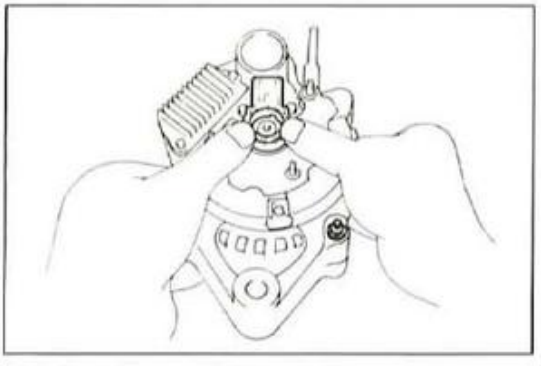
(a) Install the brush holder cover to the brush holder.

(b) Install the IC regulator together with the brush holder as shown.



(c) Install the five screws.

(d) Check that the clearance between the brush holder and the connector is 1 mm (0.04 in.) or more.



(e) Install the brush holder cover to the rear end frame.

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